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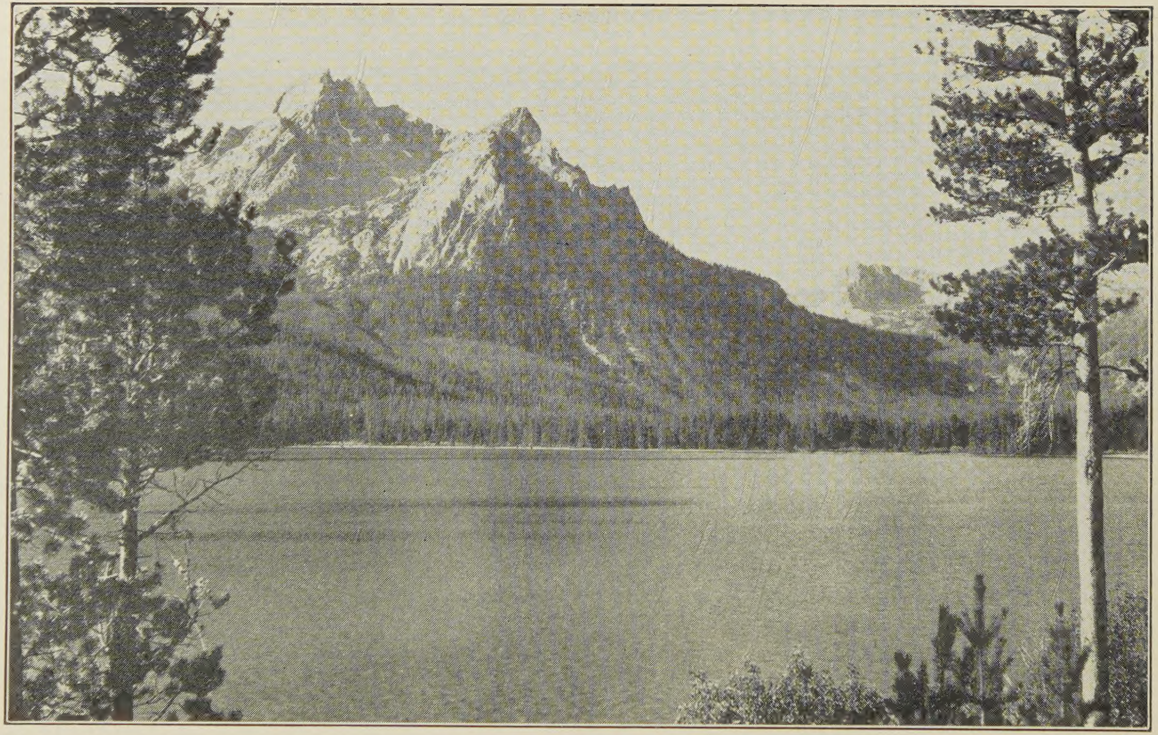

The forests and waters are the crowning glory of the Rocky Mountain region, where many of our National Forests are located. Some primitive and wilderness areas are being reserved for future generations, unspoiled and undeveloped in their primeval attractiveness. View of Stanley Lake on the headwaters of the Salmon River, Idaho.

Elements of Forestry

BY

FRANKLIN MOON, B. A., M. F.
LATE DEAN, NEW YORK STATE COLLEGE OF FORESTRY AT SYRACUSE UNIVERSITY

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THIRD EDITION

NEW YORK
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THIRD EDITION
Second Printing, January, 1945

Printed in U. S. A.

Theodore Roosevelt

WHO AS PRESIDENT OF THE UNITED STATES AROUSED
THE AMERICAN PEOPLE TO THE IMPORTANCE
OF FORESTRY AS A NATIONAL ISSUE AND
HELPED TO MAKE POSSIBLE ITS
RAPID PROGRESS IN THIS
COUNTRY

IN MEMORY OF DEAN FRANKLIN MOON

It is with sincere regret that the co-author could not participate in the revised form of this book. His name is being used as in the original form to commemorate a happy and delightful friendship, and a professional association that was always stimulating and pleasant. Dean Moon left an indelible imprint in the development of American forestry and a good name that will endure through the years.

PREFACE TO THIRD EDITION

Since the revision of this volume in 1929, there have been rapid and sweeping changes in the national conservation program. With the inauguration of Franklin D. Roosevelt in 1933 came a rapid succession of developments which have advanced the forward strides of conservation in its broadest aspects throughout the country. It has been widely recognized that one of the great internal problems of the country is the protection, rebuilding, and expansion of our vast forest resources. These are intimately interrelated with the development and protection of our other resources, which form the basic wealth of the nation. Forestry, farming, grazing, soil erosion, waterflows, recreation, and wildlife are closely associated and integrated in American life.

There has emerged an almost bewildering array of legislation and presidential enactments which are closely integrated with our social and economic development, particularly in matters of unemployment relief. Therefore, forestry and forest conservation have been given a new social and economic significance.

It is hoped that in revised form this textbook will continue to serve as useful a purpose as it has done in the past twenty years or more in many of the American schools and colleges.

I wish to express my grateful appreciation to the several federal, state, and private agencies which contributed material for the revision and especially to the U. S. Forest Service for furnishing most of the photographs.

NELSON COURTLANDT BROWN.

July, 1937

PREFACE TO THIRD PRINTING CORRECTED OF THE SECOND EDITION

As the second printing of this book was exhausted, and it seemed necessary to issue a third printing, the entire text has been revised and corrected, particularly with reference to up-to-date statistics, new facts made available or recently determined and in other ways in which the text could be improved and brought up to date. The authors have purposely left out many statistics and figures, such as prices which change from time to time, but it is believed a few were very necessary to a proper understanding of the subject.

January, 1929

PREFACE TO SECOND EDITION

To keep abreast of a subject which has been developing as fast as the science and art of Forestry is a difficult task. Noted for rapidity in organization, the American people, since the first National Forests were created some thirty years ago, have quite surpassed themselves with regard to the profession and theory of Forestry, although its practice is a variable quantity. Whereas, ten years ago, Silviculture and Forestry were practically synonymous, the ever-broadening field is now concerned with many processes in the utilization or conversion of the raw stock grown upon National and State Forest areas. Indeed, the distribution of the crop when manufactured is proving to be an important part of the economic problem.

Conditions brought about or uncovered by the World War have seriously disturbed old customs and practices. New theories concerning land use, present and future, are constantly appearing. Unless all economic signs fail, foreign markets will be unable to absorb American foodstuffs in increasing quantities; and consequently the growing of agricultural crops may be limited and specialized, with the result that only the best-located and most fertile soils will be fully utilized. In any event, the cutting out of virgin timber supplies close to centers of population, and the rapid rise in the price of forest products due to dwindling supplies and mounting transportation costs, are forcing the *growing of timber crops* to the fore. The possibility of a Canadian embargo has shown the necessity for domestic production. In fact, all signs indicate that every acre of non-agricultural soil must be put to its best use if the future lumber needs of the nation are to be met; with the present yield but one-fourth of the annual cut, intensive Forestry must be practiced on a vast scale, and lands now idle must be replanted and made productive.

The continued progress and expansion of the conservation movement can be assured only through cumulative popular education, which must reach every group and class, and must pay particular attention to children in the schools and to students in agricultural schools and colleges.

Within the decade just passed, a large number of Forestry textbooks have appeared, most of them dealing with one phase or specialty. The object of the authors of this text has been to prepare a book general in scope, gathering data from sources not readily available, and to present the information in a form easily grasped by the average student.

No chapter on Dendrology has been included, as the subject is too extensive to be treated in a general textbook, and ample material covering this field, published privately and by the various forest agencies, is to be found in any college library.

In this edition an effort has been made to bring statistics and policies up to date; and two new chapters, covering phases of State and National forest practice which have developed to a marked degree within the past ten years, have been added.

The forest regions and state problems have been handled in a suggestive fashion only, and additional details can doubtless be supplied by the individual instructor from local sources and references. To the Forest Service, which has been most generous with information and illustrations, as well as to friends who have aided with comments and criticisms, thanks are due from the authors.

FRANKLIN MOON.
NELSON COURTLANDT BROWN.

SYRACUSE, NEW YORK
January, 1924

ABBREVIATIONS

For the sake of brevity and in reiterated and frequently used expressions, the following abbreviations are generally used.

Thousand board feet	m.b.f.
Board foot (1″ thick; 12″ square)	b.f.
Thousand	M
Inches	″
Feet	′
Horse-power	h.p.
Diameter breast high (4½ feet above ground)	d.b.h.
Free on board	f.o.b.
Per centum	%
Pounds	lb. or #
Revolutions per minute	r.p.m.

1,000,000 acres are equivalent roughly to one National Forest extending 40 miles square or 1600 square miles.

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ELEMENTS OF FORESTRY

PART I

HISTORY, ECONOMICS, AND TECHNIQUE

CHAPTER I

DEFINITIONS, HISTORY, AND SCOPE

Introduction

An understanding of our historical background and development is necessary for a proper appreciation of the origin and evolving of the American system of forestry. This nation was gifted by nature with vast, rich, and varied resources. The fundamental wealth of any nation is intimately dependent upon the land resources such as soil, minerals, and forests. The prosperity of this country is largely founded upon minerals to dig, soils to cultivate, fish to catch, waters to develop and control, and trees to chop. The temperate zone forests generally produce trees most useful for building and general construction purposes. Our forests, mines, and soils were once considered almost limitless and inexhaustible. These resources have been carefully studied, examined, and partially developed — in some regions overdeveloped. From a definite agrarian population the country has gradually shifted to one comprised largely of industrial occupations. With this industrial development and increasing population has come more intensive development of our resources. It is believed that these resources are capable of satisfactorily supplying the national requirements if a carefully designed plan is prepared and executed for their renewal, protection, and perpetuation, as well as their use.

S

An awakened public opinion founded on the realization that our resources are exhaustible is largely responsible for this change in public sentiment. This change came about gradually during the period immediately following the Civil War, and has become established since the beginning of the present century. A crystallization of public sentiment regarding our natural resources led to State and Federal legislation; but public opinion and not legislation, nor even the officials themselves, constitutes the bulwark of strength in the development of thought leading to definite action in a democracy such as the United States.

Definition — Scope and Significance

Forestry may be defined as the best use of the forest. There are several definitions of forestry but all emphasize the fundamentally important principles of continuity of production and use. This includes, obviously, the protection and care of trees and forests. Under proper management and as a result of definite planned economy, our forests may contribute very vitally and importantly to the social and economic betterment of our people. Forestry is sometimes defined as the art and science of managing forests and converting the product best to serve mankind. President Theodore Roosevelt defined it as " the preservation of forests by wise use." Dr. B. E. Fernow defined it as " the rational treatment of forests for forest purposes." In the first edition of this book it was defined as the art of raising repeated crops of timber and other forest products on soils unsuited to agriculture. Graves and Guise stated that the purpose of forestry is " to obtain from forest lands and their products the greatest economic and industrial service." Pack and Gill described it as " the attempt to help nature to produce perpetually the greatest quantities of the most valuable forest products." From a broad viewpoint these products may be wood, game, recreation, or other useful services.

From earliest colonial days and throughout the westward extension of our population, the forest was regarded as a resource to be exploited. Much of it was cut and burned with ruthless disregard for its future, especially in the matter of frequent and

Fig. 1.—The preservation and maintenance of the best forest, water, forage, and wildlife conditions are paramount in the forestry program. Forests insure a continuous and even flow of water used for irrigation, power, and drinking purposes by the people in our teeming cities.

devastating fires. Forestry means the managing of our forests to serve the present requirements of our people as well as the requirements of future generations. There is now an attempt to treat the forests as a source of regular crops. The farmer tills his soil for an annual crop. The forester manages the forest for periodic crops that may mature every thirty, fifty, or one hundred years. The future crop depends very much upon present care and treatment. Cutting the annual or periodic crops of timber is the basis of sustained yield forest management. This contrasts with the practice of former exploitation, wastage, and lack of a provident program for the future needs of our people. Thus the practice of forestry means the growing and use of successive crops of timber best to serve mankind. These are the basic principles of perpetuation and of continuous production.

Fig. 2.—Fortunately a few virgin stands of timber are being reserved for the enjoyment and pleasure of future generations. View of the famous Heart's Content Forest of virgin white pine in the Alleghany National Forest, Pennsylvania.

But perpetuation does not mean preservation without use. The name of our Federal Forest Reserves was changed to National Forests because the very word " reserve " implied that these areas were never to be cut nor forest lands used except for park or scenic or recreational purposes.

A broader and finer conception of the benefits that may accrue to our people from the proper care and management of our forests has come within recent years. Forestry and forest conservation are among the great internal problems that must be met and solved by our people.

Forests occupy over one-fourth of the total area of the country. Forestry is sometimes regarded as a part of agriculture. It is also described as a part of engineering because it deals with constructive effort and building, and engineering must be conducted in connection with well-managed forest properties. It is true that forests are a soil crop; but forestry is closely allied to business, transportation, and chemistry as well as to agriculture and engineering.

Forestry is planned economy for the business management and utilization of our forest lands. These often include grazing, mining, water power development, irrigation dams, reservoirs for municipal water facilities, recreational development, propagation and care of wildlife, the preservation of scenic beauty spots and views, the prevention of erosion, and the maintenance of an even and continuous water flow.

Thus forests mean a living community of trees wherein many people reside or from which they secure the source of their livelihood. Although forests are generally far removed from our great urban centers, our people are vitally dependent on them. They keep our supply of drinking water pure and continuous, they furnish cross ties to make our railroads and subways safe, many of our great, tall buildings in nearly every part of the country are supported on wooden piling. Our telephone and telegraph systems are maintained on far-reaching lines of wooden poles. Furniture is largely made of wood because of its beauty or grain and warmth of color and touch. Our floors and interior furnishings as well as most of our dwellings are built of wood. Thus wood has an important place in our everyday lives. Forests furnish timber, minerals, furs, and other by-products of wildlife. They support sheep for wool and mutton, cattle for beef and hides, resin for the manufacture of naval stores, and a great variety of other products. From trees, in addition to lumber, cross ties, poles, veneers, barrels, etc., are obtained fuel for heating and cooking, paper for our daily newspapers, books, and wrappings as well as a great variety of manufactured products — rayon, maple syrup, oils, fiber board, insulation materials, perfumes, dyes, drugs, a wide variety of chemical products, tar, pitch, turpentine, paint, rubber, and cork. The films shown in the moving picture theatres are partly made from products of hardwood distillation; our automobiles roll on rubber tires. Light and heat may come from a hydro-electric development many miles away in the forest wilderness. Thus forests affect our daily lives in the matters of health, comfort, and general happiness.

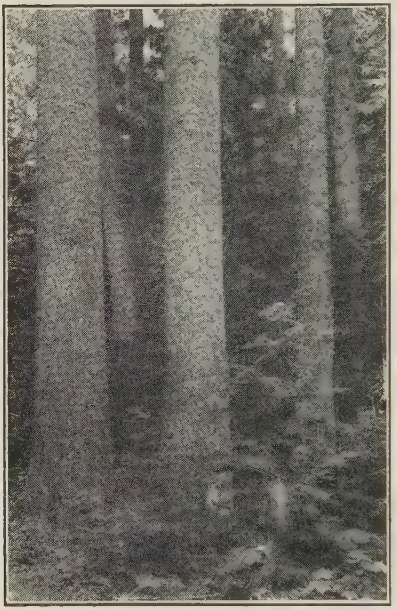
Fig. 3.—Some unusually fine specimens of western white pine timber ranging from 30,000 to 80,000 b. f. or more per acre in the Inland Empire.

Forest industries furnish employment for vast numbers of men. One company employs 15,000 men. Approximately one million people derive their livelihood from the work of the woods or in industries dependent upon forest products. Thus about five million people secure directly their very bread and butter from the broad field of forestry. Indirectly large additional numbers secure their livelihood from banking, transportation, export trade, and the many ramifications of business life dependent upon the industries using the forest as a source of their raw materials.

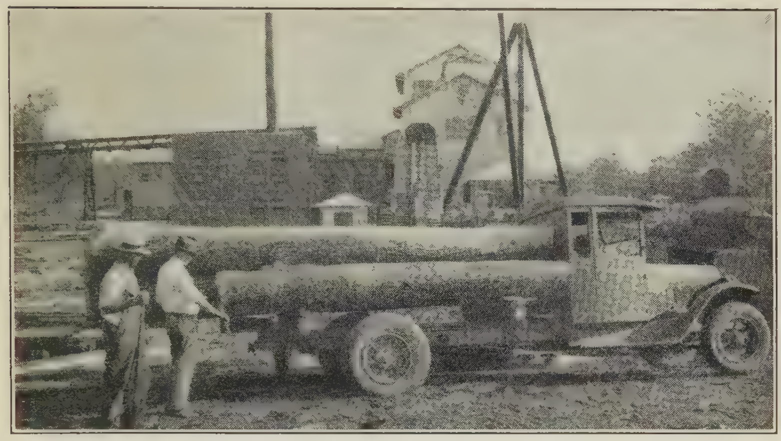

Fig. 4.—Hardwood logs making up a load of about 750 b. f. delivered at a sawmill in eastern Tennessee. With the improved highways the motor truck is widely used as a means of bringing in logs from long distances to the sawmills.

Forests as a Part of Our Rich Native Resources

Originally our forests covered about one-half the total area of the country. Owing to the clearing of timber lands for farms and the frequent lumbering and subsequent forest fires, about one-half of our original forest area has been cleared. Today about one-fourth of the total land area of the United States, or 500 million acres, is classified as timberland and a still larger area, perhaps 600 million acres, is potential forest land; that is, land capable of growing timber.

This country was blessed with rich native resources. Excepting Russia, the United States probably has the richest, most varied, and widely useful forests, tillable soils, minerals, and water to be found in any country in the world. Our forests were too often regarded as a handicap to the development and expansion of our civilization. They were originally the very backbone of our first export commerce, in ship timbers, spars, and lumber so much needed in the denuded regions of Europe. They furnished furs and game and shelter for the early American colonists. Our civilization has been literally hewed from the forest. Much strength of character was developed in the early American colonists as a result of this struggle against the wilderness and climatic elements. For three hundred years, the lives of our people have been intimately associated with trees and forests. Forests have contributed in no small part to the up-building of American traditions, to the strength of character of the people, to the health and very livelihood of many generations.

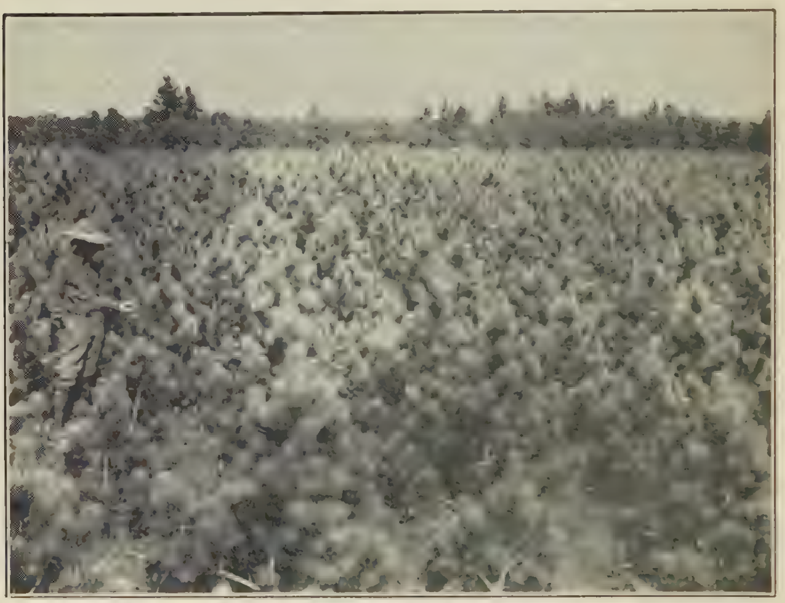

FIG. 5.—A successful Norway pine plantation on a previously logged and burned area in Michigan.

The struggle against the elements and life in the forest wilderness, the very adventure of eking out an existence under such adverse circumstances, has developed sterling traits of character among the early generations and has given the nation much of the bulwark of its strength. Mankind lived in close association with the forest. He hunted and trapped, cleared off the timber for his farms, and made his living, at least partly, from the forest wilderness.

The forest with its spiritual and cultural values no less than its material values has played its part in the evolving of the American commonwealth. Trees and forests have furnished inspiration for many songs and much poetry. Joyce Kilmer's immortal poem, " Trees," is only one example. It is instinctive for people to " get back to nature," and perhaps there is nothing so spiritually stimulating as a quiet stroll amid the gorgeously colored forests of blended hardwoods and conifers in the Autumn or a walk in the midst of the giant sequoias of California.

Forestry in the Colonial and Expansion Eras

Although we are really only making a modest beginning in our national program of forestry, the early colonists who came from England, Holland, Germany, and France were well aware of the importance of forests in their homelands. Their habits of thrift and economy made themselves apparent even in the earliest colonial days. Probably, in this country, the first expression of public sentiment about forests was in 1626 when the Pilgrims at Plymouth passed a law prohibiting any cutting of timber without official approval. Subsequently came a number of acts relating to the prevention of forest fires in New England and the cutting of timber in that section. In granting titles in Penns Woods (Pennsylvania), William Penn insisted that one out of every five acres cleared should be left in woods. Congress in 1799 and 1817 became concerned about a future timber supply for its navy and set aside reservations of live-oaks in the South for ship timber. In 1828, President Adams reserved 30,000 acres of live-oaks near Pensacola, Florida, for the navy.

During the westward expansion of our population before the Civil War, the great treeless plains of the Middle West were settled by a throng of pioneers who came over the Allegheny and Appalachian Mountains in ox carts or moved westward via the Erie Canal. These settlers came from the well-forested East and they well understood the value of trees and forests for shade, for a home of game, for protection from biting winds, for a source of supply for fuelwood, farm timbers, etc. Many of these settlers brought seed or small trees with them from the East. Some time later, in 1872, Governor J. Sterling Morton, later U. S. Secretary of Agriculture, established Arbor Day in Nebraska.

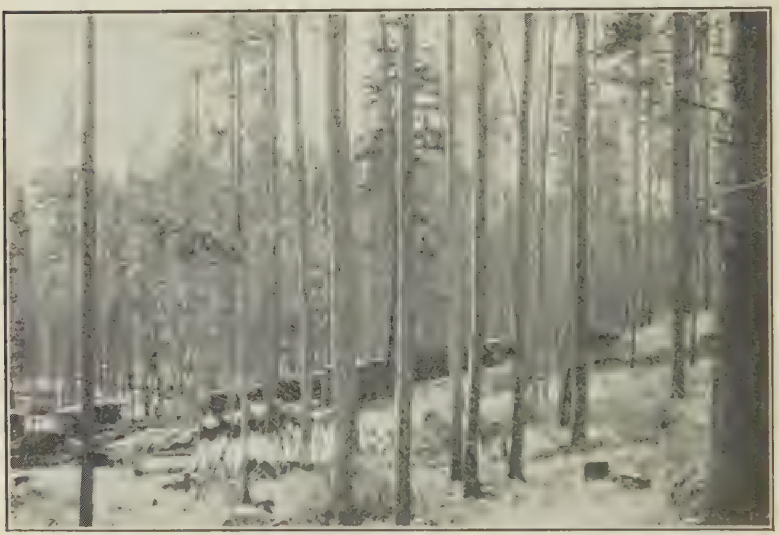

FIG. 6 Selective logging in lodgepole pine. The saw logs are cut from the larger trees, whereas mine props, cross ties, lagging and converter poles are secured from the top logs and smaller trees for use in the copper refineries and mines in the Butte-Anaconda district of western Montana.

Although our pioneer stock was tree-minded from its association with the forests in Europe and our colonists appreciated the value of forests to mankind, it was many years later before thought in this direction was crystallized in the direction of an active and effective forestry program for the entire country. Thus forestry sentiment was in the making and molding over a long period of time. Although much progress has been made in forest reservation and legislation and recently the reserved areas have been greatly expanded and the work of the woods developed, we are still on the threshold of putting our " Forestry house " in order.

Early Discussion, Writing, and Legislation

Any important national policy or program has generally required many years to develop. It required many years for the thirteen colonies to become united into one nation. The constitution was the result of many years of discussion and thought on the part of our ablest men. Many national policies have been adopted only as a result of much thought, discussion, writing, and finally of legislation. So it was with our forestry program. Throughout the nineteenth century there were two broad divisions of thought respecting our forest resources. One group felt that the forests were inexhaustible and limitless and a barrier to the development of our civilization. Trees were of little value and were thoughtlessly lumbered and burned. More forests were burned than were cut by the lumberman's axe. Another group of thoughtful, forward-looking, and representative citizens began to forecast the results of the rapid exploitation of all our resources. There was much thought, writing, and legislation affecting our forests. These formed the background of a great tide of public sentiment which developed and finally assumed such large proportions that legislative action was taken by both Federal and State governments.

Early in the nineteenth century a famous French botanist and scientist, André Michaux, traveled widely in this country and wrote an excellent book, " The North American Sylva." In Massachusetts a survey was made of the forest resources in 1837. Reverend Frederick Starr wrote a treatise on American forests in 1865. Harvard University established a chair of tree culture and started its famous Arnold Arboretum. Lectures on trees, planting, and various phases of forest culture were offered in many colleges and universities. Forest reserves, parks, and game refuges were established. As a result of the stories of the famous pioneer explorer, Jim Bridger, the Yellowstone Park Timberland Reserve of two million acres was set aside in 1891.

How European and American Forestry Came About

European forestry came into being on a wave of vital fear of a fuel famine. For centuries the forests were the only source of fuel; directly through the form of wood or in the converted form of charcoal. Wood was also important for home building, ship construction, furniture, etc.; but for many years prior to the discovery and use of coal, oil, gas, and electricity, wood was the only fuel available. The prospective lack of wood in some sections of Europe, the increasing population, the gradual cutting of the forests, and the danger of insufficient regrowth of timber caused the people of Germany, France, Italy, Switzerland, and other countries to inaugurate measures for growing sufficient wood for their fuel requirements. This interest in conservation developed gradually over a period of nine hundred years or so, beginning one thousand years ago. Even today, in many sections of France and Italy, there is little if any coal or fuel oil and therefore wood is still the main source of fuel. But with the danger of a fuel famine vanishing, wood is still a material of almost universal use. The very prosperity and happiness of the people of some countries like Sweden and Finland are intimately related to the timber resources and industries. Without the important lumber, pulpwood, wood pulp, and paper exports, Sweden and Finland would not be in their present prosperous condition.

In the United States, concurrently with a reckless and prodigal waste of our soil, forest, and mineral resources during the past century, a genuine fear of a timber famine, chiefly in construction work, was aroused. Wood was the principal desideratum in the early crusade for better American forestry. Closely associated with this great objective was the preservation and maintenance of a supply of forage and water for local and regional uses. In the development of our National Forest system, wood, forage, and water to serve the local communities were of paramount importance. From these original objectives the purpose and meaning of forestry have expanded to include many other objectives as described elsewhere.

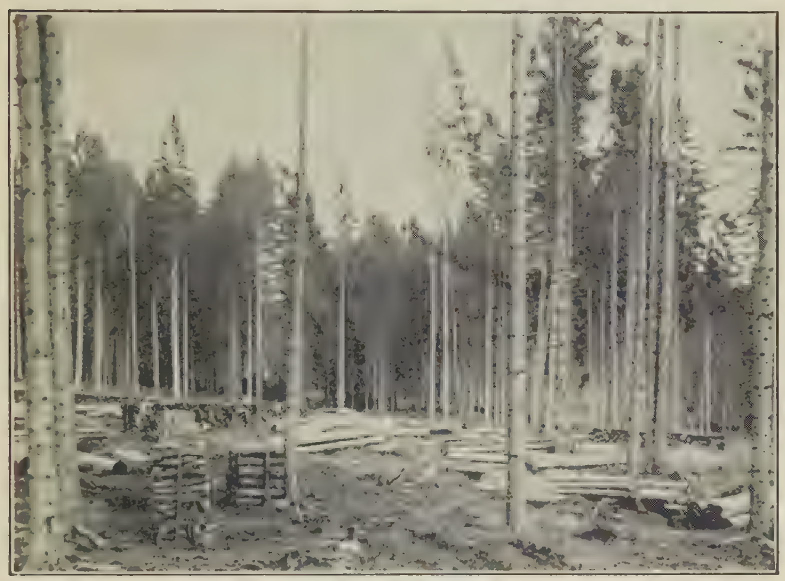

FIG. 7.—Almost complete utilization as found in a typical logging scene in Norway spruce in Germany. The larger trees are cut into saw logs. The top logs and the smaller trees are cut into pulpwood. All logs are stripped of bark which is used for tanning purposes. The stumps are cut low, the top branches and small pieces corded and stacked for fuelwood. Even the smallest limbs and branches are utilized. Later the stumps are grubbed out and converted into charcoal.

Influence of European Forestry on Developments in the United States

This country owes a great debt of gratitude to European forestry and to those responsible for the advancement of its technique, particularly in Germany, France, and Switzerland. There are places in Europe where forests have been under skillful and successful management for centuries and in extreme cases up to one thousand years. The art of forestry developed in a very intensive way because prices for forest products were sufficiently high to justify these advanced methods.

A particular kind of silviculture was applied to each type of forest, and the most minute calculations made as to the influence of climate and soils, tree spacing, and other factors upon the life history of the forest. Rotations of seventy-five to one hundred and fifty years were common. Great expense was involved in protecting the forests from fire, insects, disease, and other injurious agencies.

Models of successful forestry practice were developed in the Black Forest, Saxony, the Boehmerwald and at Heidelberg in Germany, at the Sihlwald near Zurich in Switzerland, and at Versailles, Compiegne, Fontainebleau, Nancy, the Landes region, and other parts of France. These furnished stimulating examples for American travelers and public spirited citizens who pointed the way for emulation in this country.

Three eminent and well-trained foresters who were born and trained in Germany exerted a particularly favorable and helpful influence on the development of forestry in this country. These men were Bernhard E. Fernow who become chief forester of the United States and later headed the Schools of Forestry at Cornell, Penn State, and Toronto; Filibert Roth who served the government with Fernow and for years was head of the Forestry School at the University of Michigan; and Carl E. Schenck who was forester for the Biltmore Estate in North Carolina and organized the Biltmore Forestry School in 1898. Gifford Pinchot and Henry S. Graves, both chief foresters of the United States, received their professional training in forestry in Europe, notably at the French School of Forestry at Nancy, and at several German schools of forestry. Many other American foresters have received a part of all their training in Europe.

While the ideals and techniques of European forestry are most helpful and serve as excellent standards, it is not believed that many of the methods used in Europe can be directly applied in this country. There are so many different species and so many various forest types, economic conditions, and forms of ownership in the United States. Prices for products do not justify intensive forms of silvicultural practice as yet. Distances are great between sawmills and the consuming markets. Thus conditions are not at all similar or comparable. It is believed that we must develop our own system of forestry, closely integrated with our social and economic conditions and policies.

The Public Domain — Source of Federal Forests and Parks

A large share of the total area of the continental United States was acquired through purchase and treaty. This constituted the so-called Public Domain or lands owned by the Federal Government. It was acquired principally from the Louisiana Purchase in 1803 and subsequent treaties* with Mexico, Spain, and Great Britain, the annexation of Texas, and the Alaska purchase from Russia. Practically all the land west of the Mississippi River was acquired in this way, and at one time the Public Domain occupied more than two-thirds of the area of the United States. Originally it was believed that these public lands should pass through sale into private ownership and theoretically this would furnish a great source of revenue adequate to finance the cost of government. Through an ordinance of 1784 grants were made to soldiers of the wars of 1776 and 1812. The Homestead Law of 1862, the Timber Culture Act of 1873, the Timber and Stone Act of 1878, and the Desert Land Acts of 1877 and 1890 permitted vast areas to be deeded, largely to private individuals. Enormous land grants were made to the railroads to subsidize and encourage the westward extension of lines and subsequent colonization in the Prairie States and the Far West. About 64 million acres of swamp lands were granted to states in the hope that they would be reclaimed through drainage. Valuable grants of land were made to individual states, known as Sections 16 and 36 of each township, and generally referred to as school sections. The administration policies of many states in handling these school sections have not generally been satisfactory either from a national or state conservation viewpoint.

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*Spain's cession of Florida in 1819, Oregon settlement with Great Britain in 1846, Mexico's cession of California, Utah, Nevada, and the Southwest in 1848, Texas Purchase in 1850, and the Gadsden purchase in 1853.

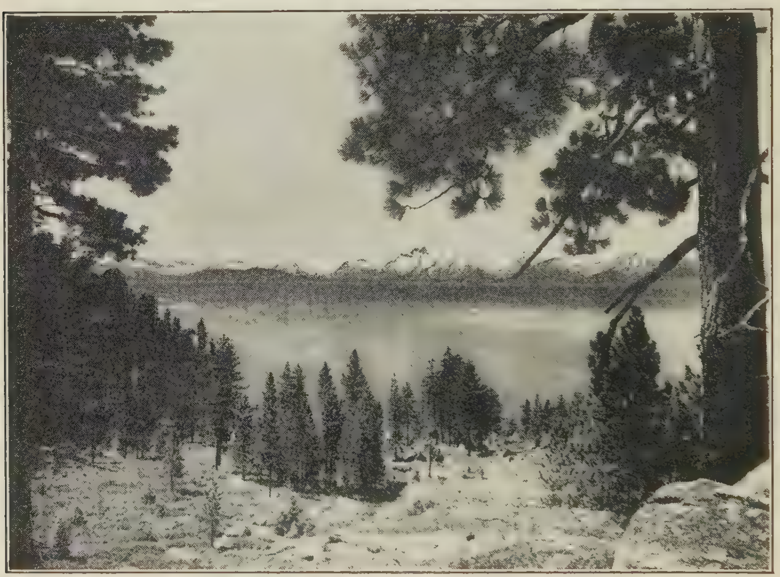


Fig. 8.—Forests of ponderosa pine around Lake Tahoe in California. In the distance are snow-clad peaks above timber line. This line varies from around 6,000′ to 12,000′ in elevation in various parts of the West, depending upon local conditions and latitude.

This policy of disposition resulted ultimately in the development of the richer agricultural lands as well as timber, mineral, grazing, and associated resources. The Public Domain, as far as timber and grazing rights were concerned, came to be known as " no man's land." The resultant trespass, theft, and exploitation by private and corporate interests that took advantage of the best and most accessible lands through loose and inefficient administrations left the remainder for later reservation for such purposes as the government saw fit.

Late in the nineteenth century, public sentiment, aroused by a few far-seeing men of devotion to public service and interest, resulted in laws leading to the formulation of federal land policies in relation to natural resources. The Act of 1891 authorized the President to set aside Public Domain timberlands as forest preserves. As early as 1872, the Yellowstone National Park, now containing over two million acres, was created out of the Public Domain. It was not, however, until 1897 that an act for the practical administration of our National Forests was effected.

Now approximately one-fifth of the original Public Domain has been reserved for the general welfare of the people, including National Forests and Parks, Indian lands, coal land withdrawals, reclamation lands, and other lands with mineral deposits.

The various acts mentioned above, especially that of 1891, permitted the removal from exploitation of some of the best timberland from the Public Domain in the Rocky Mountain and Pacific Coast states. The best timber and grasslands, however, were taken up under the Homestead, Timber and Stone, and other acts and passed eventually to large corporate ownership. Fortunately what was left of the Public Domain was partially reserved for the purposes as mentioned. There is a vast area of 173 million acres of unreserved and unappropriated Public Domain which has recently been taken over to a large extent by the Grazing Bureau of the Interior Department. Of this vast area there are 23 million acres classified as forest land. The present Public Domain is confined principally to the eleven far western (Rocky Mountain and Pacific Coast) states. Much of it, at high elevations and in remote locations, will probably not enter the commercial markets for many years.

Arbor Day and Its Significance

When the settlers from the East rushed westward to settle the fertile Middle West, they remembered the many benefits and friendly atmosphere created by trees. The treeless plains were unprotected from the biting winds of the North and the hot, dry winds from the West and South, and there was no natural shelter for man or beast. Governor J. Sterling Morton of Nebraska, later Secretary of Agriculture, formulated the idea of Arbor Day. From this humble start in 1873, the celebration of Arbor Day spread to the surrounding prairie states and finally reached every state in the nation. From these modest beginnings came an interest in planting trees, not only individually such as on school grounds and lawns, but general forest planting by service and luncheon clubs, American Legion posts, civic groups, colleges and universities as well as by towns, cities, villages, and the states. The cumulative effect of this wave of enthusiasm has culminated in the planting of many millions of trees each year.

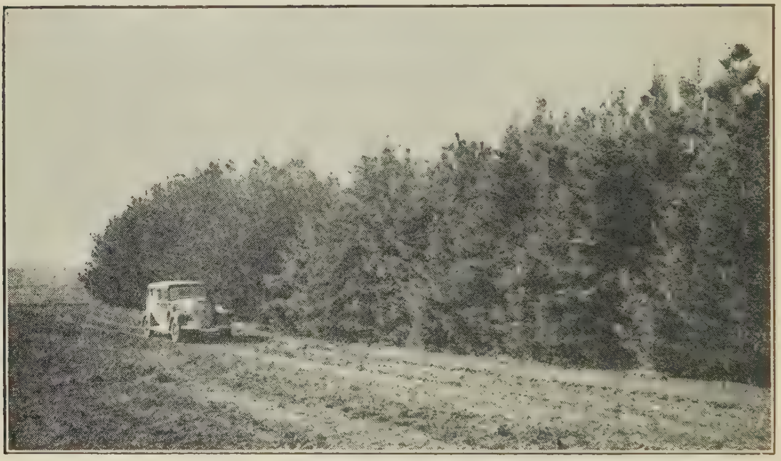


Fig. 9.—White spruce and ponderosa pine plantations forming shelterbelt near Mandan, North Dakota. These are among the most successful drought-resisting species used in the northern plains. Arbor day gave tree planting a great impetus on the Great Plains and prairies.

Thus Arbor Day built up the public interest in tree planting. For many years an annual program has been held in nearly every school in the country. This program has created in the youthful minds an interest in trees and forests which has helped immeasurably to make our people tree-minded. Whereas, formerly, only a few trees were planted, several thousand are now being planted by the same schools on city reservoirs, watersheds, abandoned farms, odd corners or perhaps on land to screen off an unsightly swamp or a city dump ground. On the outskirts of nearly every community there are always places where trees may be profitably planted for aesthetic and spiritual values and perhaps for commercial purposes as well.

Arbor Day is now generally announced by proclamation of the governors or fixed for a definite date in the year. Thus in Alabama, Illinois, Iowa, Maine, Michigan, Minnesota, Wisconsin, and Washington, the day is set by the governor. In some states, as in Colorado, California, Florida, Virginia, Louisiana, the fixed day is named and followed by custom or by statute. In the North, Northwest, and Northeast these Arbor Days generally occur in the spring. In Georgia, Arbor Day is the first Friday in December; in Florida, the first Friday in February; in Louisiana, the second Friday in January; in Texas, February 22. .

To Arbor Day may be attributed much of the popular feeling and affection for trees and appreciation of the myriad benefits they bring to mankind.

Development of National Forest System

It was the law of 1891 signed by President Harrison which provided for setting aside forest reserves, later known as National Forests, from the Public Domain. This date really marks the active inauguration of our federal system of forestry. Although Presidents Harrison, Cleveland, and McKinley set aside considerable areas under this act, it remained for President Theodore Roosevelt, guided and advised by Gifford Pinchot, who was then chief forester, to expand greatly the areas of National Forests in the Rocky Mountain and Pacific Coast states and to give forestry wide recognition and acceptance throughout the nation. At first there was vigorous opposition to the setting aside of an area of about 150 million acres of National Forests from the Public Domain. A considerable area of some states, as Idaho, Colorado, Montana, Washington, Oregon, and California was set aside for National Forests.

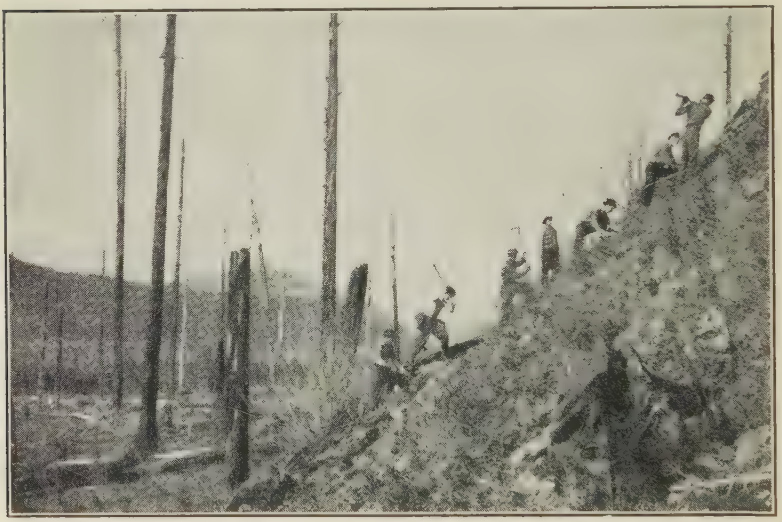


FIG. 10.—Planting crew and foreman reforesting a badly burned area on the Olympic National Forest in Washington. The two-man crew method is used, one man making the hole with a mattock and the other inserting the tree and firming the soil about the roots.

The citizens of those states feared that the timber, mining, grazing, and water resources would be reserved or " bottled up " from development. Later, in 1897, came the enactment of a law which provided for the administration and management of this vast resource. The spirit of exploitation and of wastage was widespread, particularly in the West. The viewpoint of conservation and of current use with provision for the future was just emerging in the public conscience and existed largely in the minds of a few far-seeing and thoughtful leaders of that era. During the régime of President Theodore Roosevelt, 148 million acres were added to the National Forests. In 1897, the administration of the federal forests was placed in the Department of the Interior. A Division of Forestry existed in the Department of Agriculture, but this offered only technical advice in forestry and conducted studies of our trees and forest resources. In 1901, the Division of Forestry became the Bureau of Forestry, but it was not until 1905 that the activities in the two federal departments were united and the responsibility for the forest reserves was placed under the Forest Service, as the name of the federal organization became known. Under the leadership of Gifford Pinchot, ably followed by Henry S. Graves, William B. Greeley, R. Y. Stuart, and F. A. Silcox, the Forest Service enjoyed widespread public recognition. The personnel was greatly expanded and the work at Washington decentralized by setting up regional offices so that foresters would have a more intimate knowledge and understanding of local problems and would handle them more promptly and satisfactorily.

In 1911, the Weeks Law provided for the purchase of eastern National Forests for the major reason of protecting the navigability of streams flowing from them. Under this law several million acres of cut-over timberlands have been acquired in the South, Appalachians, Lake States, New England, Pennsylvania, and still later in Ohio, Illinois, Iowa, and Missouri.

Development of State Forestry Activities

Concurrently with the growing interest in conserving our forest resources following the Civil War, doubtless stimulated by the first federal action in 1876, some progressive and active leaders in several states attracted attention to the need of stopping the prevalent disastrous fires and the wasteful cutting of our virgin forests. Arbor Day and the enthusiasm engendered by the movement played an important part.

The first efforts resulting in legislation came in 1885 when four states, namely, New York, Ohio, Colorado, and California, took action. In New York a Forest Commission was created to administer the forest preserve of 700,000 acres and supervise fire protection. Ohio created a Forest Bureau with investigative, advisory, and educational duties. Colorado established a Forest Commissioner and California a Board of Forestry to collect and disseminate information, experiment in tree planting, and aid in enforcing forestry laws. Then quickly followed a series of legislative efforts throughout the nation. Each state which formulated legislation passed laws intended best to suit local conditions and requirements. The laws passed in the Prairie States differed vitally from those passed in New England. Fire protection was most urgent in some; tax exemptions or bounties to encourage planting prevailed in the Prairie States of the Middle West; forest surveys and investigations

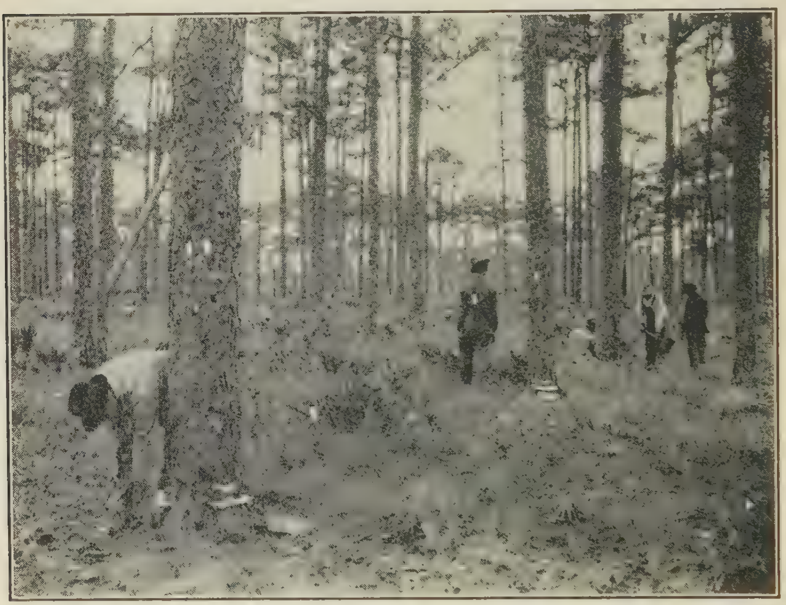


Fig. 11.—A typical view in a turpentine orchard in northern Florida, showing a crew hanging cups preliminary to gathering the resin which flows after periodic chipping. Most of our naval stores come from second-growth forests. No trees less than 9″ in diameter should be tapped. Naval stores constitute one of the great sources of wealth and employment in the South.

were of first importance in others. Little precedent was available for procedure. It required many years to develop, finance, and organize a trained personnel. Prior to 1898 there were no forest schools to prepare professional foresters. Much public education furthermore was required. Few people understood or appreciated the objectives of forestry. Opposition was widespread from many sources and had to be overcome. Forestry literally had to be " sold " to the public and this required several decades in some states.

New England took the leadership in formulating sound policies, and Connecticut had the first trained forester in its employ. Then the movement to employ trained foresters spread over the East and Lake States to the Middle West, and to the Rocky Mountains and Pacific Coast States. The South was the last to develop state forest policies, but progress there has been notable and effective since 1920. The Northwestern States have been outstanding in their leadership in organizing efficient fire protection. The work accomplished to date in Washington, Oregon, Idaho, and Montana has been noteworthy in successful cooperation between federal, state, and private interests to prevent the ravages of forest fires.

By 1911, 25 states had some forestry organization. Financial support was still inadequate and much public education is still needed. In that year the Weeks Law provided federal cooperation in fire protection and in 1924 it was amended by the Clarke McNary Act to provide federal aid in reforestation. In 1919, there were 11 states cooperating in protecting about 60 million acres; by 1931, 38 states cooperated with the Federal Government in protecting 227 million acres or nearly one-half the total forest area of the country. Now 42 states are organized with effective forestry organizations, each employing from a few up to 70 or more professional foresters. The principal activities are the improved protection and management of state forests, the protection of private forest land, the growing and planting of trees, and the protection and culture of fish and game. Research activities and public education and advice also constitute important phases of state forest work. Many private, county, village, and corporate owners of timberland have been encouraged to practice forestry on a sustained yield basis in many of the states.

On August 29, 1935 President F. D. Roosevelt signed the Fulmer Act which is a cooperative effort of state and federal forestry agencies to provide for " a stable, adequate, and effective program of state-forest-land management and use."

Development of Private Forestry

Except for the Public Domain, most of our timberlands were owned by private individuals and companies through grants of land. Subsequently, through the disposition of the Public Domain by the Timber and Stone and the Homestead Acts, much timberland came into private ownership. Today individuals and private companies own 79% of the total forested area, the remainder being in public ownership.

It was natural that public agencies, chiefly federal, should take the leadership in the development of forest policies. Because of the lack of immediate profits, private forestry was the slowest to develop. There are many more difficulties confronting forestry for private owners than in public forests and parks. Farmers own most of the private timberland in the form of farm woodlands. These comprise over 25% of the forest lands of the country. East of the Rocky Mountains, the farm woodlands include more than three-fifths of the forests. A crude but often effective method of forestry has been practiced on our farm woodlands. These have been cut over from time to time to supply fuelwood, fencing, bridges, foundations, lumber for dwellings, barns, and miscellaneous uses about the farm.

Probably the most active leadership in private forestry has been taken by several large lumber, pulp and paper companies in their extensive holdings. Many of them are now managed under a sustained yield plan. Many fishing and hunting clubs, resorts, and private parks are engaged in the practice of forestry chiefly in protection from fire and other injurious agencies, the planting of open, fire-swept, or cut-over areas, and the cutting of the woods in such a way as to insure their continuous growth and productivity.

Under the leadership of the federal and state forest services, demonstration forests and forest schools, there has been a definite improvement in private forestry in many parts of the country, notably in the Pacific Northwest, the South, the Lake States, and the East. Several lumber associations employ foresters to assist in plans for cutting and protection programs that will insure future growth. Some lumber and pulp companies maintain nurseries, fire protection organizations, and staffs of foresters to handle their properties on a definite plan of forest management.

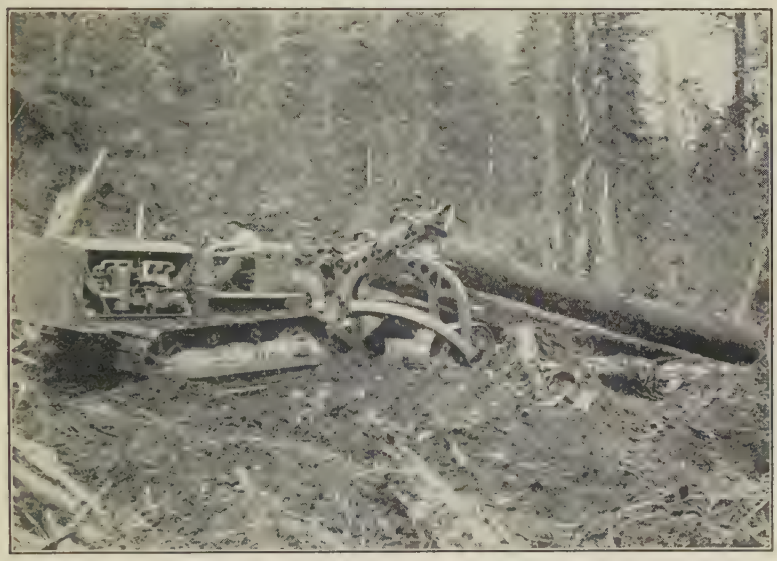


Fig. 12.—Caterpillar Diesel 75 h.-p. tractor, equipped with Hyster arch and hoist, yarding hemlock and spruce logs in the Olympic peninsula of Washington. This Diesel tractor consumes 25 to 30 gallons of fuel oil costing 5 cents per gallon in an 8-hour shift. From 5,000 to 10,000 b. f. are delivered per trip, 3½ trips per hour, and approximately 21,000 b. f. per hour.

Forestry as a Profession

Forestry as a profession has greatly developed and expanded during recent years. The expansion is especially due to the governmental enactments creating the Civilian Conservation Corps and the Soil Conservation Service and the enlargement of National and State Forest and Park systems. There are about 4000 men in the professional organization known as the Society of American Foresters. The federal and state forestry services have greatly expanded personnel to take care of the additional responsibilities. The enrollment in the twenty-five professional forestry schools has increased enormously. About five times as many young men are studying forestry as were so occupied about ten years ago. More than 6000 students are in the professional forestry schools and over 700 degrees were granted in 1937.

Many have been attracted to forestry through their camping, hunting, fishing, and tramping experiences or perhaps a summer vacation spent in some camp in the woods. Many young men are imbued with a strong sentimental and romantic interest in the out-of-doors. This is a natural and healthy reaction. But to earn one's livelihood from work in the woods or industries dependent upon them is quite different. The attraction in the youthful mind to a study of wild flowers, birds, or insects, the challenge of mountain climbing, the natural desire to " get back to nature," and the healthy environment of the woods may be the first approach to forestry.

Forestry implies a broad scientific interest in trees and forests as well as a desire to improve our woodlands and to assure an adequate supply of timber and other products for future generations. There is by implication, therefore, a strong spirit of public service and a desire to make this country a happier, finer, and better place in which to live. One looks forward to many years, perhaps generations, before the final results of present plans and action may become apparent. Therefore, there should exist in the prospective forester a genuine love of the forest and the objectives of forestry. A sentimental and romantic interest is desirable, but he must have the ability to apply in a practical way his knowledge of wood, trees, and forests so that he may make a living from the profession as well as serve the country for the future.

Forestry has recently assumed an important part in the life of the nation. The forester must understand our economic and political systems and understand professional ethics. He must have as well a detailed knowledge of trees and forests and the part they may assume in our national economy. Fundamentally he must have an adequate knowledge of trees as plants, how they grow, compete with one another, resist injurious agencies, and reproduce. He must also have an understanding of how trees may best be converted into materials useful in human economy.

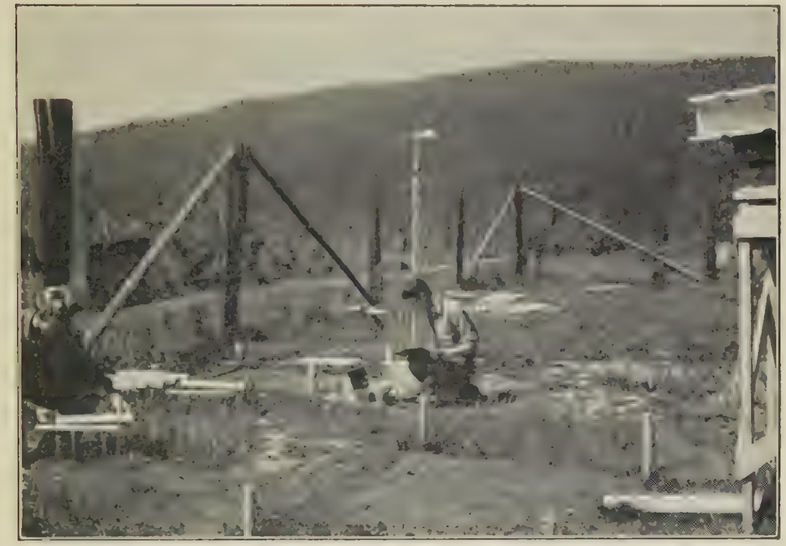


FIG. 13.—Scientific apparatus in use at the Priest River Experiment Station on the Kaniksu National Forest in northern Idaho. Full-sun inflammability tests are being made. Wind gauges, thermometers, and other instruments are used to keep records of the direction and intensity of the wind, temperature, humidity, and other factors bearing upon fire hazards, leading to improved methods of fire protection.

The forester must have a thorough education similar to that demanded for the other professions, as law, theology, engineering, medicine, and agriculture.

Those entering the profession should enjoy robust and vigorous health. During the first apprentice years, the forester may have to camp out in northern climates in the wintertime. His work may require going into remote wilderness areas on horseback or by canoe, skis, or snow-shoes. He may be in watery swamps a good part of the day. He may undergo extremes of heat and cold or work under the most arduous and difficult conditions, such as fighting fires with little water or food. The utmost resourcefulness and the highest degree of morale are necessary in order to do the work successfully and occasionally to get along with the minimum of clothing, food, and other comforts. He must frequently be satisfied with the pleasures of woods life — and they are many. One who insists upon the customary pleasures and surroundings of city life may not enjoy life remote from the movies and other urban entertainments. He may be required to carry a heavy pack or burdensome instruments on long journeys into inaccessible mountains, swamps, or otherwise difficult regions. Physical endurance, a cheerful disposition, resourcefulness, and leadership are outstanding requirements for one going into the profession.

Some looking forward to healthy outdoor work to improve their physical condition may be keenly disappointed. Generally speaking, it is not a satisfactory profession for consumptives or those with any chronic organic difficulty. Some follow a fortuitous method in taking up the profession. One should study the advantages and disadvantages of forestry as a profession. What foresters have done in the past twenty years is a good guide for the future. Too many accidentally take up the profession or follow it largely as a result of their romantic and sentimental interest in the great out-of-doors.

Forestry is an exceedingly interesting profession. One constantly faces many problems, new policies, new conditions. He meets interesting people and generally works under very pleasant and healthful surroundings. Forestry is a constructive profession. It is building for the future. It is concerned with growing new and better forests and in converting the product best to serve mankind.

Summarized briefly, the principal qualifications for success in the profession are: (1) A sound and technical training in a professional school of forestry. This generally requires four, five, or six years, depending upon the nature and objective of the training. (2) Resourcefulness. Every field of work requires a large amount of resourcefulness. Closely related to this feature is strong character, native honesty, keen sense of responsibility, and initiative. (3) Robust and vigorous health. (4) A spirit of public service and a strong desire to improve the conditions of the country with respect to its forest resources.

Educational Facilities for Training in Forestry

Technical education in forestry was at first patterned largely after European educational policies. There are now twenty-five colleges or universities offering professional training in forestry, most of which are state-supported schools. Many of these offer the Bachelor of Science degree at the end of four years and some offer opportunities for advanced degrees in Master of Forestry, Master of Science, and Doctor of Philosophy.

Facilities for professional training in forestry have greatly expanded during the present century. Forestry education was started by Dr. Carl Schenck at the Biltmore Forest School at Biltmore, North Carolina, in 1898, and the first College of Forestry followed shortly thereafter at Cornell University, at Ithaca, New York. The first permanently established school was at Yale University, New Haven, Connecticut, in 1900.

Yale, Harvard (at Petersham, Massachusetts), and Duke, at Durham, North Carolina, are exclusively graduate schools and conduct considerable research in connection with their activities. There are two state-supported ranger schools located at Wanakena, New York, and Mont Alto, Pennsylvania.

Most of the forest schools are undergraduate in character but some offer graduate work as well. Among the forest schools in the East, excepting the above-mentioned graduate schools, are those at the University of Maine at Orono, Pennsylvania State College at State College, Pennsylvania, University of New Hampshire at Durham, Connecticut State College at Storrs, and the New York State College of Forestry at Syracuse University. In the Middle West are the forest schools at the University of Michigan at Ann Arbor, Michigan State College at East Lansing, Purdue University at Lafayette, Indiana, Iowa State College at Ames, University of Minnesota at Minneapolis, and the University of Missouri at Columbia. In the Rocky Mountain region are Colorado State College at Fort Collins, University of Idaho at Moscow, University of Montana at Missoula, and Utah State College of Agriculture at Logan. On the Pacific Coast are the schools of forestry at the University of Washington at Seattle, Oregon State College at Corvallis, University of California at Berkeley, and Washington State College at Pullman. In the South are those at the North Carolina State College at Raleigh, University of Georgia at Athens, Louisiana State University at Baton Rouge, and the University of Florida at Gainesville. Forestry training of a non-professional nature is offered at a large number of prominent schools, such as the University of West Virginia at Morgantown, University of Vermont at Burlington, Ohio State University at Columbus, Massachusetts State College at Amherst, University of Tennessee at Knoxville, University of Virginia at Charlottesville, Brown University at Providence, Michigan School of Mines at Houghton, Colgate University at Hamilton, New York, University of Idaho (southern branch) at Pocatello, Idaho, and many others.

Courses in forestry are being offered in a number of agricultural, engineering, liberal arts colleges, as well as at state teachers' colleges, normal schools, and junior colleges. Some offer forestry training in the fundamentals which lead to later attendance at schools of professional rank.

The curriculum of the professional schools consists of two years of fundamental training in the sciences underlying applied forestry, as botany, zoology, chemistry, physics, and mathematics. The last two years are generally devoted to the principal subjects of forestry, as forest protection, silviculture, forest management, forest utilization and forest policy, and economics. Attention is also given to the more important cultural subjects, as English, economics, history, psychology, sociology, and foreign languages. Forestry has to do with mankind as well as the business of growing and using trees. Relations with the public, especially in federal and state forestry services, are sometimes as important as the general field of growing, protecting, and using timber. Therefore, a forester should be well-trained in the humanities as well as in the science and art of forestry.

Fig. 14.—The Stuart nursery near Alexandria, Louisiana, showing seed beds of longleaf and slash pines. Seedlings six months old started in the spring are used for planting the following winter. Under the favorable conditions prevailing, millions of trees are now being planted on cut-over and burned lands in many parts of the South. This nursery has a production capacity of 50,000,000 trees. Federal nurseries are maintained in 14 states.

Some of the schools offer specialties in addition to the general course in forestry, which is very similar to the courses offered in the European schools. Among these specialties are pulp and paper manufacture, logging engineering, forest pathology, forest botany, forest entomology, dry kiln engineering, timber preservation, lumber merchandising, forest recreation, landscape forestry, park engineering, city and county forestry, etc.

Some schools are training men specifically for work in the forest industries. Certainly forest schools are better equipped and manned than other schools to train men for the lumber, pulp and paper, veneer, woodworking, cross tie, pole, and similar industries.

Principal Branches of Forestry

Since the very beginning of instruction in forestry, the subject has traditionally been divided into five major branches as follows:

1. **Forest Protection.** This includes the protection of trees and forests from injurious agents. These are principally fire, insects, and fungi. One of the most important deterrents to the progress of forestry is the danger from fire. More trees have been destroyed by fire than have been cut by the axe. A forester must know the life history of insects which attack both living trees and lumber, and other products derived from them. Tree diseases known as fungi are exceedingly injurious. Wind, frost, lightning, shifting sands, landslides, and avalanches are also injurious to tree growth. Forest protection is a prerequisite in all plans for forest management. It is fundamentally important in the progress of all forms of forestry.

2 2. **Silviculture.** This is the art of producing, reproducing, and growing a forest best to suit the wishes of the owner. It is also described as growing a forest to secure the greatest volume of wood in the shortest length of time and with the least expense on a given tract. It is the application of the knowledge of trees and how they grow and are influenced by each other. It is based upon silvics, which is the relation of the tree to its environment. Derived from two Latin names, silviculture

literally means the culture of the woods and involves the life habits and behavior of trees growing in a community of trees known as a forest. Every forester must know the life habits of trees and methods of reproduction, character of growth, when they reach maturity, and what conditions are necessary to improve upon nature in growing a stand of timber in the shortest length of time.

3 3. Forest Utilization. This includes the harvesting of mature or immature forest crops. It involves the most profitable and efficient use of forest products. It embraces the wide field of the conversion of standing timber into forms and sizes that are most useful to mankind. It includes felling of the trees, skidding and hauling of logs, transporting them to sawmills, the manufacture of trees into various useful forms, and the merchandising and distribution of the final product. It also includes the properties and uses of wood. Seasoning and conditioning of the product and the preservative treatment of lumber, cross ties, poles, piling, etc., to increase their life in service are included. The degree of utilization determines the intensity with which silviculture may be applied in the woods. It is the keystone of successful forest management. Until our vast timber resources are completely depleted, forest utilization constitutes a most important phase of American forestry.

4. Forest Management. This is the application of the principles of forestry to a given area. It includes the measurement of the present and potential yield of the forest. The survey and mapping of timber tracts, the construction of roads, bridges, fire towers, ranger cabins, and the telephone lines so necessary in any program of forestry are included. Such subjects as forest administration, forest organization, and forest finances are within the scope of this phase of the subject. It also includes the formulation of management plans or working plans under which forest properties are continuously managed.

5 5. Forest Policy, Laws, and Economics. These include the principles which determine the administration of a forest for best permanent management. The formulation of laws and

Forest Protection 2/ Silviculture
Forest utilization 4/ Forest management

policies as expressions of public opinion in the various states and in the Federal Government are included. Included also are the history and development of forestry, taxation, and other laws and policies which affect a system of forestry, questions of supply and demand, ratio of depletion and growth, and other broad considerations affecting a program of forestry.

Objectives of Forestry

Forestry seeks to make the timberlands and standing timber accomplish those things which are of the greatest present and future benefits to the people of the nation. Thus the objectives may vary in different parts of the country and even among the various states. Certainly the objectives of forestry are quite different in a high mountain region like Switzerland, or in our own Rocky Mountains, from those in a lowland country like Holland or in the lower Mississippi Valley. It is generally recognized that the maintenance of a continuous forest cover on our mountain slopes has a very direct bearing upon many phases of human activities. It is of paramount importance that a national plan be devised and executed for the management of our vast forest domain which covers approximately one-fourth of the total land surface of the country.

Until recent years the greatest single objective of forestry was to grow enough wood for the nation, and immediately, to avert a prospective timber famine. With efficient protection from fire, insects, and fungi, proper cutting measures of mature timber, and the abandonment of many farms to forests, it is likely that we shall be able to grow all the timber we need and a sufficient surplus to build up an important and profitable export trade. The fact that there is little likelihood of a serious timber famine, however, is no reason why we should not have and execute a plan for the rebuilding, maintenance, and perpetuation of our vast timbered areas.

Summarized, the objectives of forestry are as follows:

1. **Wood Production.** An abundant, readily available, and reasonably priced supply of timber must be assured for

Wood production [illegible]

[illegible]

future use. From a national viewpoint, this is the greatest single objective. We must have a plentiful supply of lumber for shelter and construction, cross ties for railroads, fuelwood for heating and cooking, poles for telephone and telegraph lines, piling for wharves, docks, and most of our heavy structures that do not rest on bed rock, paper for our newspapers and books, timbers for mining, materials for boxes, furniture, tools, implements, toys, and a myriad of other everyday uses.

2. **Conservation of Water.** In California and many sections of the Rocky Mountains, water for irrigation, for power, and for drinking purposes is of vital importance. Our navigable streams must be properly maintained without silting. Floods, erosion, and the washing of our steeper slopes must be prevented. Our waters must be properly protected and a constant and even flow maintained for all of these and many other purposes. For fishing alone the conservation of waterflows in our forests is of vast importance.

3. **Conservation of Wildlife.** Forests and wildlife are inseparable. The forest is a natural home of fur-bearing animals and game. About thirteen million people annually take out licenses to hunt and fish. Any system of forest management must properly contemplate the protection, propagation, and continuance of our wildlife.

4. **Forage for Livestock.** In many sections of the West and South, millions of cattle, sheep, horses, and goats secure their forage from the grasses found in timbered regions. There are eighty-three million acres of range land in the National Forests of the West. An important share of our beef, mutton, and wool is obtained from vast herds of domestic animals, especially in the Rocky mountains and western states. Range management is of first importance in some regions and is closely related to forestry. Many farm woodlands are used for grazing in the eastern and central states.

5. **Aesthetic and Spiritual Values.** Without trees, our landscapes would be dull indeed, sordid, barren, and unattractive. Forestry has a definite obligation to maintain the beauty

ESTHETIC = BEAUTY

[illegible] facilities ?/ Climatic [illegible] spots, outstanding scenic features, and wooded glens for the benefit of future generations. Where forests are cut under a plan of management, trees should be left standing along the streams and roadsides for the shade, scenic effects, and aesthetic values which are enjoyed by so many people. Trees and forests have definite spiritual values which are coming to be recognized more and more. The quiet, calm, and repose of the forest wilderness are being more and more sought by people who spend most of their lives in the nervous tension of the larger urban centers. In many of the National Parks, National and State Forests, and State Parks the aesthetic and spiritual values of forests are coming to be recognized and appreciated.

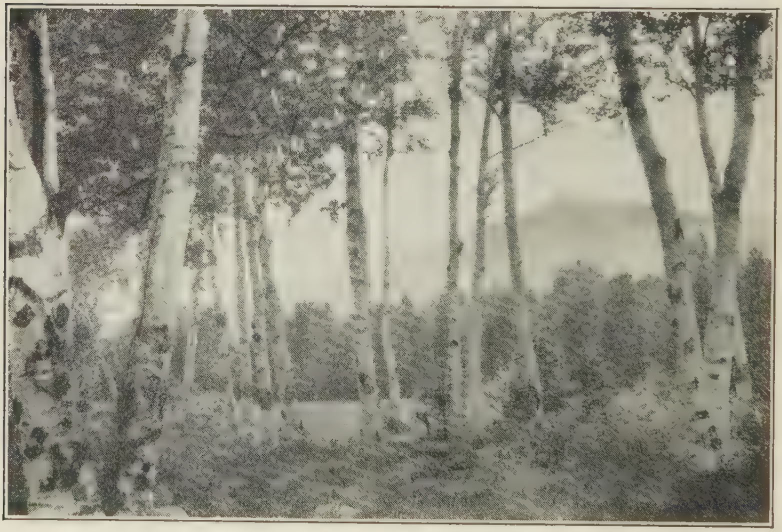


FIG. 15.—Forests of definite aesthetic and spiritual values are coming to be more and more appreciated by the millions who go annually to them in inexpensive motor cars and on improved highway systems. Typical white birches found in the White Mountain National Forest on Mount Washington in New Hampshire.

6. **Facilities for Recreation.** During pioneer and colonial times people had little interest in the forest, except as a source

of wood for fuel and construction and for game. The forest was generally regarded with awe and perhaps as a fearsome and unpleasant place. The increase of population concurrently with the almost universal use of automobiles and the development of excellent highways have literally placed the forest at our back door. Millions are visiting our forests for vacationing or other forms of recreation through fishing and hunting. Approximately fifty million people annually visit our National Forests; some ten million people visit our National Parks and Monuments, and many more go annually to our State Parks and Forests. With increasing time for leisure and with low priced transportation, more and more people are going to the forests, not only for vacationing and recreating their minds and bodies, but for camping, hiking, mountain climbing, and similar recreational pleasures. Many camps of the Y. W. C. A., Y. M. C. A., Boy Scouts, Girl Scouts, Camp Fire Girls, Salvation Army, and similar organizations for under-privileged children are being provided in our public parks and forests and many areas are definitely set aside for these purposes. Forests have a very positive health and recreation value, and in some places the greatest single objective of forest management is to provide adequate and pleasant recreation facilities.

7. Climatic Influences. Forests have a very definite effect on climate. They tend to ameliorate the extremes of temperature, making hot summers a little cooler and the coldest winter days less extreme. Many thousands of shelterbelts have been constructed to prevent the blowing of sand and to decrease the chilling and drying effects of winds. Many miles of trees have been planted as snow breaks. Furthermore, forests retain snow longer in the springtime, thus causing the more gradual melting of snow and decreasing the likelihood of floods or serious erosion. Enormous quantities of water are transpired through the leaves of trees. Thus forests are likely to be cooler than open areas of the same region. Trees do not actually bring rain but they have a tendency to conserve moisture and to influence precipitation at least to a small extent.

Emergence of Forestry as an Accepted Part of Our National Welfare and Prosperity

With the inauguration of President Franklin D. Roosevelt on March 4, 1933, a new concept of the part forestry may play in the life and economy of the nation came into being. Forestry had been widely discussed and advocated. There was a vast area of National Forests and Parks which were largely undeveloped and poorly protected from fire, insects, and disease. Many areas needed tree planting and many forests were in need of thinning or cutting. Relatively little had been accomplished in improving the general condition of our woods, both private and public; fires were still widespread, relatively few trees had been planted on cut-over areas and on deserted farms and burned areas, and disease and insect attacks were rampant.

With the coming of the Civilian Conservation Corps program about two million young men received training and experience in two thousand camps in every state. More than eight hundred million trees have been planted since 1933; fire towers, telephone lines, and fire breaks have been constructed; brush fires have decreased; roads have made forests accessible; erosion has been checked; hunting and fishing conditions have improved; recreational facilities have vastly increased, and much other constructive work has been done in all of our forested regions. These young men, heartened in morale and improved in health, have carried back to their homes the spirit of conservation and a knowledge of the importance of planned economy for our forests.

Forestry became intimately related to social relief and the alleviation of distress due to the economic depression, the drought, and floods. A succession of presidential proclamations and congressional acts brought forth the Soil Conservation Service, Plains Shelterbelt Project, forestry in the Tennessee Valley Authority, the National Resources Board, the Public Domain Grazing Bureau, and greatly enlarged areas for National Forests and Parks.

The work of the Civilian Conservation Corps program directly contributed to an increased acquisition of State Forests and Parks, because these camps could only be located on federal and state properties. There are over 4,000,000 acres of state and local parks in every state contrasted with almost complete absence of these facilities before 1933 in many states. In order to secure the benefit of these camps many areas for State Forests and Parks were acquired and put in good condition by the Civilian Conservation Corps.

Fig. 16.—Black bear at a den tree in the forests of West Virginia. Bears do relatively little damage to property and generally are not to be feared by mankind. They should be protected, for they lend a great deal of interest to forest life.

A great increase in the demand for trained foresters followed these programs. Many young men have sought training in forestry at the twenty-five professional forestry schools, the enrollment in which has about doubled in the past few years. There are about 4000 men in the Society of American Foresters, the professional organization of this group. The public has become forestry-minded. Conservation of our forest resources is generally accepted as a vital part of our national well-being and program for the future.

Notable Figures in the Development of American Forestry

There are many personalities around whom the formation of public opinion was focused during the developmental stages of American forestry. Each played his part befitting the times in which he lived. Each was sufficiently clear-sighted to envisage the requirements of the nation and to do those things that helped to advance the cause of conservation.

Among the early notable figures who contributed to the development of thought in this direction was Franklin B. Hough, first Chief Forester of the United States (then known as Special Agent) who served from 1876 to 1883. He was the man of the hour to put the first molding of sentiment into public action. Many writers, as Joaquin Miller, John Burroughs, John Muir, Stuart Edward White, and Emerson Hough, served to stimulate public action. Early explorers, scientists, and geographers, as Zebulon Pike, Lewis and Clark, André Micheaux, a French botanist, and W. H. Brewer of Yale, helped to awaken interest in our then unknown and romantic western frontier and to direct attention to its possibilities in serving the nation. David Douglas, the Scottish botanist, explored Oregon from 1826 to 1830. S. B. Green in Minnesota, J. T. Rothrock in Pennsylvania, G. Sterling Morton of Arbor Day fame in Nebraska, and E. A. Bowers of the Interior Department, all made splendid contributions to the development of public opinion. John Muir of California played a vital rôle in influencing Presidents and Congress to provide for National Forests and Parks. He pointed out in vivid fashion that any nation which neglects its forests and soils will wither and decay and sometimes perish, as Asia Minor. Muir, with his wide knowledge of western conditions, made many trips to Washington, wrote books and magazine articles, and by his persistence, courage, and indomitable will played an important part.

Three German-born and trained foresters — B. E. Fernow, Filibert Roth, and C. A. Schenck — brought to this country the best ideals and standards of European forestry. Gifford Pinchot and Henry S. Graves served a notable purpose in bringing the subject of forestry and forest conservation to wide public attention. Gifford Pinchot was a great crusader for the cause. He awakened public appreciation of the social and economic values of the forest and fortunately was a close intimate friend of President Theodore Roosevelt and served in his so-called Tennis Cabinet. It was through Pinchot's close association with Roosevelt as Chief Forester that the great enlargement of the National Forest program came into being and saved millions of acres of Public Domain from further despoliation and wastage. Still later, Chief Foresters William B. Greeley, R. Y. Stuart, and F. A. Silcox solidified, expanded, and developed our National Forest system. They also stimulated activity in state and private forestry.

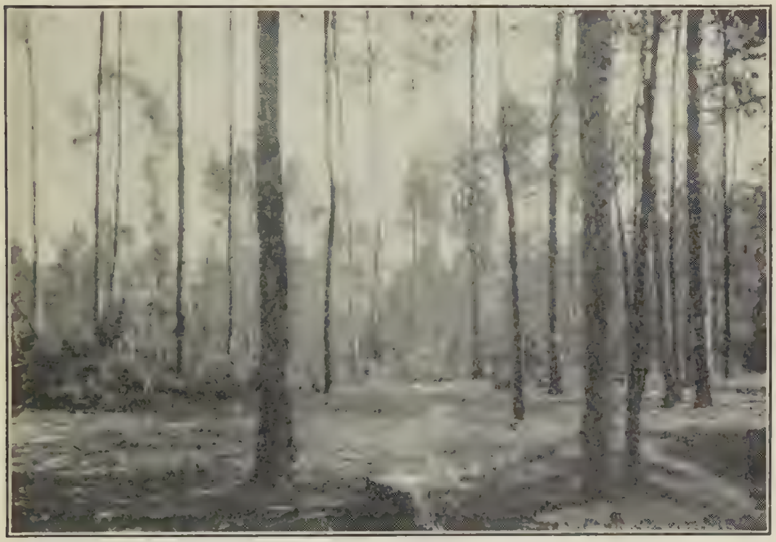


FIG. 17.—Mixed hardwood and pine stand selectively logged in the South. Only the larger trees that will yield present profits were cut. Too frequently in the past, small trees that only yielded a 2″ x 4″ dimension or narrow boards were cut to the serious detriment of both the present yield and the future growing condition of the forest.

In the meantime many notable figures, such as Charles Lathrop Pack and his son Arthur Newton Pack of the American Tree and American Nature Associations, and Ovid Butler of the American Forestry Association made splendid contributions to the public education of people regarding the importance and value of our forest resources. Some research specialists, as Raphael Zon, Richard T. Fisher, and Earl Clapp, made definite advances in the knowledge of forestry. Such notable educators as Henry S. Graves, James W. Toumey, and H. H. Chapman of Yale, together with S. T. Dana of Michigan, R. S. Hosmer of Cornell, Hugo Winkenwerder of the University of Washington, J. A. Ferguson of Pennsylvania State College, Henry Schmitz of the University of Minnesota, G. W. Peavy of Oregon State College, Hugh P. Baker, F. F. Moon, and S. N. Spring of the New York State College of Forestry, G. B. MacDonald of Iowa State College, and Walter Mulford of the University of California made definite contributions to the development of education in American forestry. Such administrators and public spirited citizens as Nathaniel Eggleston, Overton W. Price, Frederick Olmsted, George D. Pratt, Austin Cary, and John C. Merriam assisted notably in the work.

Within recent years, President Franklin D. Roosevelt has made most significant contributions and given country-wide recognition to the development of forestry through the National Recovery Act, the Tennessee Valley Authority, the Civilian Conservation Corps program, the Soil Conservation Service, and the National Resources Board, some of which are now functioning among the governmental agencies. He has enlarged and developed the Federal Forest Service and Park Service programs.

CHAPTER II

ECONOMIC, SOCIAL, AND TECHNICAL CONSIDERATIONS

Multiple versus Restricted Purposes

The meaning, significance, and objectives of forestry have greatly expanded within recent years. Forestry is essentially a local or regional problem. It must fit the local social and economic requirements. The objectives in one state or region may be quite at variance with those in others. In some regions, forests have their highest utilitarian value in conserving waterflows for irrigation, power, or potable purposes. In the Rocky Mountains an adequate supply of forage for cattle and sheep is of prime importance and most National Forests in that region are used as important sources of forage. In California, water is of first importance for irrigation purposes. The maintenance of an even flow of water in our navigable streams was the reason for the purchase and establishment of eastern National Forests. Naval stores are the principal product and objective in growing forests in some regions of the South, such as northern Florida and parts of Georgia. The maintenance of the most attractive scenic and aesthetic effects is of paramount importance in the forests of our resort sections, notably in the White Mountains, Green Mountains, Adirondacks, the mountains of northern Maine, and many other regions of the country which have developed as important resort and vacation lands. Forests to prevent erosion or the washing of soils into the streams and storage dams are of great importance in the Tennessee Valley and throughout the South. Trees as windbreaks and shelterbelts are of vast importance in the Great Plains region. Trees for shade purposes about our homes and along the highways and city and village streets are of outstanding importance in every part of the country. A picnic and camp ground without trees would be unattractive indeed. Forests as the home of fish and game are the paramount objectives in some sections. Timber production is important for construction materials in nearly every region.

Thus, multiple-purpose forestry has been given wide recognition. In some states and regions, all of the above purposes may be served. The primary purpose of forestry is to produce wood for building, but this original objective for protecting, maintaining, and perpetuating our forests has been expanded to include many other associated and often more important purposes.

Abandonment of Farms to Forests

It has been said that if our fertile Middle West had been settled first, much of the land cleared for farms in the East would still be in forest. It is true that many areas have been cleared for agriculture that should have been left permanently in woods. Farmlands began to be abandoned soon after the Civil War, both in the South and throughout the East and Northeast. As soon as the native richness of accumulated decayed vegetation was depleted by tillage for crops, many of these lands were abandoned and quickly grew up in trees. Many lumber operations have recently been undertaken in Virginia and North Carolina on lands that were in cotton, tobacco, or corn before the Civil War, and plowed rows are still visible in the forest floor. Even in the thickly populated state of New York, land began to be abandoned as early as 1880. This farm desertion continued at the rate of 40,000 acres per annum and has increased during recent years. There are said to be 10 million acres of abandoned farmland in New England. Over 5 million acres are found in New York state alone. Many million acres of abandoned farmland are found in the southern states. Many of these naturally revert to forest cover. A recent census report shows that there has been an increase of 23.7%, or over 35 million acres, in farm woodlands during the five year period from 1930 to 1935. Thus the area of farm woods has risen to 185,474,965 acres. This represents nearly two-fifths of the total commercial forest area in the country.

During the recent economic depression there was some migration from industrial centers to rural communities known as the " back to the farm " movement. This, however, was more than offset by the increased abandonment of farmlands. There has been a very significant shift in land use from tilled lands to pastureland, and then from worn-out pasturelands to woods. Sometimes there is a direct shift from cropland to woodland. The vast national program under the Soil Conservation Service is working extensively toward the planting of the better land with soil-building plants and young trees to prevent erosion and gullying. The lower grade lands that were formerly tilled or in pasture have been permitted to revert naturally to tree growth or will be planted to a surer and more profitable crop in the future. Thus it is apparent that the acreage of farm timberlands has vastly increased during the past half century and is

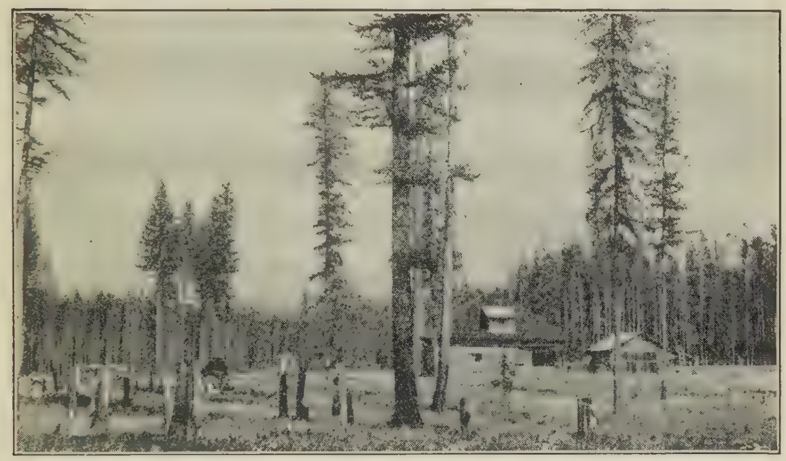


FIG. 18.—Homestead in Blackfeet National Forest, Montana. Formerly there was a strong demand for all tillable lands in the National Forests. Many of these attempts at farming failed and the land reverted to forest. Most of these trees are western larch.

likely to increase still further. Agriculture is being restricted more and more to quality soils. It is becoming apparent that lands cleared by the early or more recent settlers at tremendous labor and expense have constituted a great economic waste.

Many studies of land-use problems and programs are being conducted in all parts of the country, so that each area may be devoted to its most productive use, whether they may be in agriculture or in forestry. Former farm lands are being forested and assigned to recreation, through hunting and fishing, or publicly owned forests and parks. In some states, as in New York, a definite program has been formulated to purchase these abandoned farmlands at a cost of from $2 to $5 per acre and to plant them with trees. A constitutional amendment was passed by the people in New York in 1931 to support a $20,000,000 tree-planting program.

It is evident from the above that recent developments are in the direction of increased areas devoted to forest culture. It is thus apparent that there is less likelihood of a timber famine for the future.

The New Public Domain

The history of the disposition of the Public Domain is marked by misuse and wasteful exploitation of unsurpassed forest, soil, and mineral resources. Although the settlement of the Great Plains and the prairie regions and the pushing of civilization to the West Coast contributed immeasurably to the upbuilding and prosperity of the country at large, this chapter in American history is regarded generally as one of wasteful exploitation of capital resources and assets. Now millions of acres of these once rich public lands in the Lake States and South that were presumably given away at little or no cost for settlement purposes are reverting to public ownership, after the soils have been eroded or wasted, the forests denuded and often burned, and much of the mineral resources have disappeared. In many of the Lake States and states of the South, notably in Florida, Louisiana, and Texas, tax-delinquent lands are reverting to public ownership. In some states, they revert to the local town or county governments; in others to the state government.

This has become a serious financial burden upon the local communities, towns, counties, and states. It is estimated that over 50 million acres of land, drained of rich natural resources, are tax-delinquent throughout the nation. These may form the bases of new state, community, town, or federal forests. Many areas may be purchased for $2 to $4 per acre. Many additional millions of acres are now being exploited pending the completion of timber cutting and will become a national liability. Thus the problem of this great new Public Domain, made up of tax-delinquent lands, has become a challenge and a threat to the prosperity of many sections of the country.

FIG. 19.—Well-timbered slopes mean a maximum of water retention and a minimum of erosion. Forests act as a sponge in holding back rain and melting snow on erosive hillsides, in silting of streams and valleys with detritus, and in generally preventing damage by floods.

Even in National Forests, lands that were once settled for agricultural purposes have been deserted, after a few brief years of cultivation, and have reverted to state ownership, causing confusion in the administration of many of these forests.

Forestry and Recreation

One of the most important uses of forests is for recreational purposes. With increasing leisure time, the almost universal use of automobiles concurrently with the building of highway facilities into our more attractive forest regions, millions are now going to the forest in place of thousands a few years ago. A vast industry closely related to forest recreation has been built up in our forest regions for general health, recreation, fishing and hunting, and relaxation. Many sections of the country, as northern Maine, New Hampshire, the mountains of California, northern Wisconsin, northern Minnesota, the Pacific Northwest, and Colorado have shown the way to the interdependence of these recreational facilities and local employment or profit. The forests provide attractive opportunities for vacationing, hunting, fishing, swimming, and other recreations. In some sections near large cities this recreational use of the forests has become a real problem. Over 60 million people annually enjoy the recreational facilities of our National Forests and around 20 million people, our National Parks. Many more millions enjoy facilities provided by state forests and parks.

Many local and state-wide committees and commissions have been formulated to study this problem and to provide adequate facilities for recreational outlets. Special provision is being made for the following types of recreational use:

1. **Roadside Areas.** A large proportion of those who visit forests for recreation travel by automobile. They do not generally enter the forest, for they are interested chiefly in picnicking and resting in attractive locations along the main highways, of which there are over 3 million miles in the United States. Even where commercial forestry is practiced, roadside strips, particularly along streams, glens near waterfalls, etc., should be retained for recreational development.

2. **Camp-site Areas.** Many recreationists, especially those traveling by automobile, with or without trailers, plan to spend their vacations in camp-site areas. This requires recreational planning and landscaping of high quality. These camp grounds are generally located away from roadsides and main trails so that complete rest and freedom from noise may be enjoyed. Excellent camp-site facilities are provided in many of the National Forests and National Parks as well as state forests and parks in most of the forest regions. In some sections the proper regulation and provision for camp-site areas have become a vital problem.

3. **Summer or Seasonal Residence Locations.** Special provision is made in our National Forests for cabins, summer homes, and even hotels, resorts, group camps, stores, and various services. The Angeles National Forest in southern California is the most notable example where a very important income is secured from so-called special-use permits for summer-home sites. Altogether the Forest Service provides summer-home sites for about one-half million special-use permittees and their guests, and revenue of over $150,000 annually is created from these special uses. Space of one-quarter acre to one acre is frequently provided for these special areas. Many permits are granted to Boy Scouts, the Y. M. C. A., Campfire Girls, Girl Scouts, and church organizations for summer-camping purposes in many of our public forest areas.

4. **Specially Reserved Timbered Areas.** Within recent years special areas having unusual scenic values have been set aside for future use and enjoyment. These are sometimes classified as superlative areas that are of surpassing interest and have unusual inspirational values, primitive or virgin timber areas, as those in the redwoods of California and the white pines in Pennsylvania, New York, and New Hampshire. They have been set aside for their scenic, scientific, and popular interest and for wilderness areas which are intended to preserve large tracts of remote virgin timberland without encouraging permanent inhabitants or the extension or building of highways.

Wildlife and Game Management

Wildlife is inseparably associated with forestry. Hunting and fishing are intimately related to the forest and its management. The original definition of the word forest meant a place for game. The forester in England was originally concerned principally with the woods as a gamekeeper. Both for recreational enjoyment and from a commercial viewpoint, wildlife directly affects the lives of many of our citizens. Approximately one million dollars per annum are taken in by each of several states and by the Federal Government as well for licenses. About 13 million licenses for fishing and hunting are issued by the states each year.

FIG. 20.—Buffalo as seen on the Kaibab National Forest, Arizona. Buffalo herds once roamed the Great Plains in vast numbers. They were considered limitless and inexhaustible. Fortunately, steps are being taken to preserve and renew our forests before they are completely wiped out. Only a few buffalo remain of the vast original herds, but steps can be taken to increase the herds in the future.

The economic value of wildlife alone has been estimated as many millions of dollars. The direct values of wildlife have been estimated by the Forest Service at over 400 million dollars and the recreational values expressed in hunters' and fishermen's licenses and in the money spent for these purposes at about 300 million dollars. The meat and fur values alone are estimated to be 160 million dollars.

In Europe, hunting is preeminently the sport of royalty, the nobility, and the wealthy classes, and in spite of dense population and intensive developments of their forests, better hunting and fishing are generally less available there than in this country. The American plan, in contrast to European procedure, is to provide hunting and fishing for all who wish to enjoy it. In accordance with democratic American principles every effort is made to encourage and maintain the best wildlife conditions for as large a number of people as is possible. In some of the more settled sections of the country, notably in Pennsylvania, excellent hunting and fishing are still provided.

A regular census is now taken of our wildlife population. The principal location for big game animals is in our National Forests and Parks on the Pacific Coast and in the southern Rocky Mountain regions, notably in California and in Wyoming. The grizzly bear has almost disappeared but is found chiefly in Montana and in Wyoming. The elk is found chiefly in Wyoming, Montana, and Washington. The antelope is found principally in Wyoming and Montana. Moose live principally in the Lake States, Wyoming, and Montana. Deer are usually found in California and in the southern Rocky Mountain and the northern Rocky Mountain regions. Mountain sheep and goats are found principally in Montana and in Washington.

Wildlife management is directly concerned with and related to forest management. There is nothing inconsistent, generally speaking, between timber production and game production. Protection from fire is as important for proper game management as for forest management. The provision for adequate food and cover requirements for various forms of game is receiving special attention from foresters, especially on areas being planted to new trees and in woodlands where thinning and weeding are being conducted. In sections of the West the grazing of domestic animals, principally cattle and sheep, may seriously interfere with wildlife. This is a delicate question which is receiving the attention of foresters, livestock interests, and those principally concerned with game protection and management.

Excellent examples of the restoration and encouragement of game in this country are shown in Jackson Hole in western Wyoming, where a large herd of 20,000 elk has received adequate winter range and protection from hunting by the enlargement of National Park facilities. Seventy head of elk from this herd were shipped in 1913 to the Sitgreaves National Forest in Arizona, and recently this herd had increased to over 5000 head. The excessive deer population of the Kaibab Plateau in northern Arizona has been moved to other locations. The Forest Service estimates that the present deer population of 41,000 head on the National Forests in Colorado could be increased to 150,000 without interference with livestock or timber production, provided additional winter range was made available. Special game refuges have been established in all parts of the country where hunting is prohibited. Hunting and fishing are generally permitted in National Forests, except in certain game-refuge or restricted areas. Hunting is not permitted in the National Parks, but fishing is under proper restrictions. In some regions, notably the Pisgah Game Preserve, the

Fig. 21.—One of the few remaining moose left in the country. Photograph taken at Hoodoo Lake, Coeur d'Alene Mountains, Lolo National Forest, Idaho. Moose are also found in northern Michigan, northern Minnesota, and northern Maine. Our game should be protected and cultivated for their scientific value and popular interest, as well as for hunting.

success of game-management experiments has been clearly demonstrated. The herd on this 98,000-acre tract in western North Carolina increased from about 1000 in 1916 to over 5500 in 1936.

The development and extension of special game birds such as quail, wild turkey, grouse, and pheasant, are receiving wide attention, particularly in the East. According to Leopold, quail in the Central and Eastern States has been seriously reduced because of the removal of quail cover by clean farming operations and woodlot grazing.

Concurrently with the closing of certain public lands to hunting, many private game preserves have been established, particularly in the Northeast, the East, the South, and the Lake States. Over 20 million acres of state refuges have been established in the National Forests, notably in the Rocky Mountains and Pacific Coast States. Over 1¼ million acres of National Forests have been set aside as federal game preserves and over 4 million acres of our National Parks have been entirely closed to hunting.

Wilderness Areas

Within recent years considerable popular sentiment has developed to preserve for future generations so-called wilderness or primeval areas which contain few if any permanent inhabitants, provide no essential means of transportation, and are of sufficient size so that one may travel for a week or more without retracing or crossing his course of travel. Visitors to these areas are expected to provide their own means of travel either by walking or horseback, and the primitive features of the region are to be protected and preserved. All roads, settlements, power, reclamation, irrigation, or other commercial developments are prohibited. Trails and temporary shelters are provided. In 1930, the U. S. Forest Service began the policy of reserving some regions for this purpose and the National Park Service had already formulated the policy of preserving most of the parks under these conditions. Wilderness areas should be located in regions of high altitude and in generally remote mountains or regions where commercial values are low and scenic and aesthetic values are high. These areas do not lend themselves readily to timber production because of their slow rates of growth, their inaccessibility, and their low quality of timber production. Cattle or sheep grazing are not permitted but adequate facilities for fire protection are provided in the form of lookout cabins, telephone lines, protection trails, etc. The primeval wilderness condition of these areas is to be preserved. About 200,000 acres, or 300 square miles, of this type of forest are considered the minimum size for a wilderness area. There are only nine areas of one million acres or more available for this purpose. There are, however, eighteen areas of 500,000 acres, or more, and thirty-eight of 200,000 or more available for these purposes. It is expected that those attracted to these wilderness areas must travel on foot or use pack and saddle

FIG. 22—An aerial view of magnificent stands of western hemlock and Sitka spruce, as found on Admiralty Island, along the shores of Southeastern Alaska

horses or boats, or perhaps all three means of traversing these areas. Frequently guides or experienced woodsmen must be employed for thorough enjoyment of the forests. Those primarily interested in camping, mountain climbing, and vacationing in remote and solitary regions will be attracted to these areas. Complete enjoyment with a minimum of expense can be had by those desiring this type of recreation.

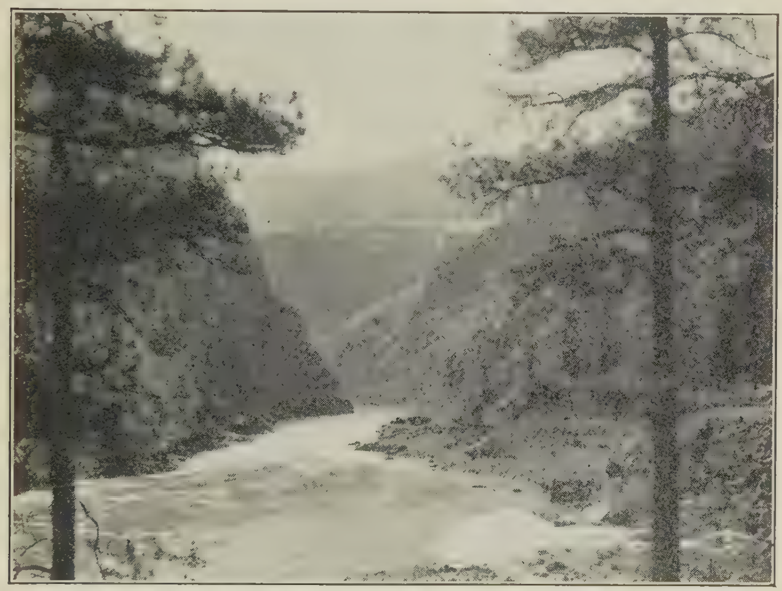


FIG. 23.—A typical canyon along the Salmon River, Idaho. In this region is located one of the few large remaining areas of virgin wilderness yet unspoiled by commercial development. It is planned to preserve a large part of this area for the pleasure of future generations, who may enjoy a pack trip or a hike into remote forest areas where the conditions are the same as have obtained for many ages.

The outstanding areas that now lend themselves to this form of wilderness are: the Salmon River section of Central Idaho; the Aroostook-Alagash area of northern Maine; several areas in northwestern and western Wyoming; the Superior region in northeastern Minnesota; the upper St. John region in Maine; the Olympic, Snoqualmie and North Cascade regions in Washington; North Yosemite, South Yosemite, Salmon-Trinity Alps, and Marble Mountain regions of California; Mt. Marcy and Moose River sections of New York; the Okefenokee swamp region in Georgia; the High Uintas in Utah; Eagle Gap and other regions in Oregon. Many other areas might be mentioned.

Forestry and Range Management

Forestry and range management are intimately related. In nearly every section of the country, notably in the Rocky Mountains and in the South, the grasslands within and interspersed among forested areas are capable of supporting large numbers of livestock. About 62% of all the western National Forests, or 82 million acres, is available, valuable, and useful for grazing. In many sections of the West, grazing is of outstanding importance, and it is a principal business in many sections of the South, Far West, and the intermountain region. Nearly 1½ million cattle and horses and over 6 million sheep and goats are grazed for several months of each year on these National Forests.

The total range area of the United States comprises about 40% of the total land surface or 728 million acres. A large portion, probably 75% of the range lands have been seriously depleted and exploited. The exploitation and the wasteful and uneconomic use of our forage resources have been comparable with the manner in which our agricultural soils and our forest resources have been managed.

Government authorities estimate that only about one-seventh of the grazing areas are in satisfactory and productive condition. Over-grazing through excessive stocking is responsible for the depletion of this vast resource which is of such wide importance throughout the western states and in many parts of the South and Middle West.

The abuse of valuable range lands and the resultant damage, not only to the range itself but, by silting, to the streams flowing from grazing areas, and the wasting and depletion of water resources on them gave rise to the passage of the Taylor Grazing Act in 1934, which is described elsewhere. This act provided for the classification of lands more suitable for agriculture than for grazing, both erosion and flood control, studies in connection with grazing, and a general rehabilitation of Public Domain areas which heretofore had not been under any active or responsible administration. It is possible that this act will be extended to maintain an increase in the water resources of the range as well as to develop certain recreational areas, to prosper fish and game management within these areas, and to correlate the grazing activities with the proper handling of several million acres of timbered areas now found within the grazing regions.

FIG. 24.—Sheep grazing on the Montezuma National Forest, Colorado. Millions of sheep and cattle graze on our National Forests and on the Public Domain. Our grazing resources have been badly mismanaged in the past as have our timber resources. The new government grazing bureau is providing for better regulation of our forage resources on millions of acres of Public Domain.

Grazing of the vast area of southern pineries has been a traditional custom since Colonial days. These forests are frequently burned over each winter or spring to improve the grazing facilities. Thus grazing and forest management and forest protection are intimately related and constitute a very serious problem in many of the eleven southern states.

The importance of grazing is being recognized by the fact that several courses in range management are now being offered, especially in the western colleges and universities. This is done in connection with the forestry curriculum or separately. Men especially trained in grazing administration are in demand in the United States Forest Service, the United States Indian Service, and in the Division of Grazing in the United States Department of the Interior.

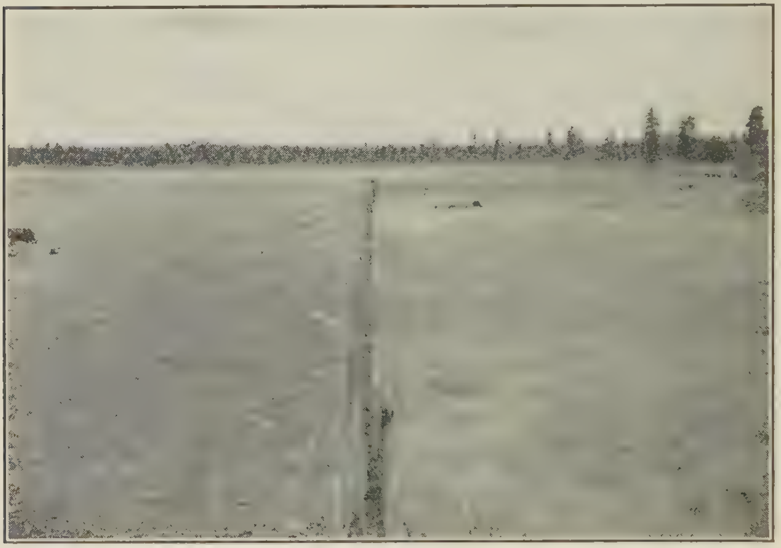


Fig. 25.—Area unprotected from over-grazing shown on the left and the area protected since 1912 on the right. Research studies have helped to determine the number of live stock that should be permitted on the various types of grasslands.

Measures recommended to help solve the major range problems are as follows:

1. Prevent further range depletion and consequent soil erosion by stopping overgrazing so commonly practiced in all the grazing regions.

2. All range lands should be placed under proper management so that there is a balance between the present and prospective growth of forage grasses and the number of domestic animals which these areas will sustain in perpetuity.

3. Readjust ownership, difficulties in administration as between public and private owners.

4. Proper integration and relationship must be built up between the livestock, watershed, agriculture, forest, wildlife, and recreational resources and opportunities.

5. By restoring a proper balance between range production and use, greater social and economic benefits will be established and a more permanent and successful form of prosperity be assured to our major range regions.

Adjustments to Political, Social, and Economic Systems

Any national plan of forestry must be suited and adjusted to the complex political, social, and economic conditions of the country. In reviewing the development of forestry in many countries, it is at once apparent that the progress and success of forestry is a direct reflection of these conditions.

Spain, Palestine, and China are noteworthy examples of national neglect of forest resources. Forests have been cut over and denuded, and these areas have subsequently been burned, grazed and eroded so that there are frequent floods. The streams are at least partially filled with silt, and vast areas of millions of acres of potentially good forest land, particularly in the mountains, have been laid waste and constitute a serious economic loss. These lands could be teeming with forests and forest industries and supporting many communities of happy and contented people.

Furthermore, vast sums of money must be expended for the importation of lumber, poles, piling, and other forms of products from abroad, whereas these materials could very well be supplied on these same mountainous areas that have become deserted lands instead of valuable and productive forests.

The United States has been a wasteful and prodigal nation in regard to its resources. This has been especially true of soil and forest resources. We have only recently become awakened to the fact that this vast forest heritage, a liberal gift of nature, should be put to its highest productive use, now and in the future.

Changing conditions require changes in forestry. Our present concept of forestry and its significance and influence is much broader and more applicable to conditions in this country than it was even thirty years ago. Any system of forestry must lend itself to the existing economic and social conditions.

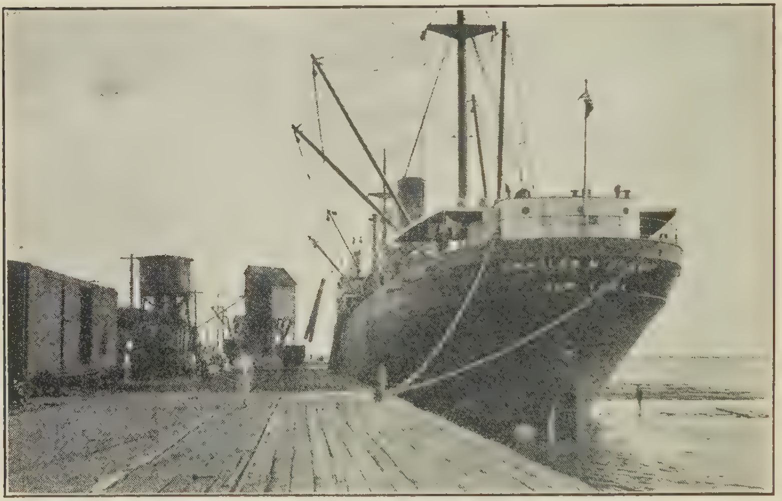


FIG. 26.—Loading lumber for export at Gulfport, Mississippi. It is possible that we may be able to develop a very profitable export trade which will inure to the economic welfare of the nation, if we protect and use our forests in the most efficient way. If we develop a good system of forestry in this country, we shall probably have ample supplies for this export trade.

We are the largest producers and consumers of forest products in the world. We are also the largest per capita users of automobiles and telephones, greatest builders of highways and producers of many products used throughout the world. It is vital that we maintain, protect, conserve, and perpetuate this vast heritage, both for present and future requirements.

Nomadic Phases of the Lumber Industry

It is an unfortunate feature of American history and methods to develop quickly and improvidently and to exploit natural resources. There have been boom days in agriculture, oil, mining, grazing, real estate, and lumbering in many parts of the country. Communities have sprung up quickly in our virgin timber, the " cream " of the forest exploited; and then some of the communities have as quickly disappeared. This has given rise to many " ghost towns " that have followed the general theory of " cut out and get out," notably in the three Lake States. These towns have been described under the colloquial term " boom and bust." Serious economic waste and many human tragedies have resulted from the quick and wasteful cutting of valuable virgin timber, the building of sawmill towns and subsequent disappearance of schools, hospitals, railroads, stores, libraries, and banks that were once dependent upon an active lumber industry. Similar events have happened in the East and parts of the South. Somewhat similar wastes occurred in the West but not to such a detrimental extent.

The lumber industry was the first industry developed by the early colonists along the Atlantic seaboard. Throughout the breadth of the nation and during its entire history, it has been one of the largest, most representative, and most typical American industries. It has pioneered in cutting the forests to provide shelter for a rapidly increasing population. Without this industry our great Central West could scarcely have been built up from the magnificent white pine forests of the Lake States and the widely useful lumber from the southern pineries. From both sections, the great treeless plains were built up with happy homes. The lumber industry has gone through the pioneer stages and has followed a nomadic career across the country: first in Maine; then, in 1850, it shifted to New York; in 1860 the center of the industry changed to Pennsylvania; and, after the Civil War during the latter part of the century, it was focused in Michigan and Wisconsin. Then it quickly dropped to the vast pineries of the South where the all-time peak of lumber production was reached in 1907. The peak of lumber production on the West Coast was reached in 1926. The last resource frontiers of our forests have been broken down. It is doubtful if lumber production will ever exceed that of 1907. Concurrently, the westward expansion of population and settlement has perceptibly slowed down. Immigration has decreased. From predominantly agricultural pursuits our people have largely changed to those of industry. Our great cities have increased their populations at the expense of the smaller communities and the farms. Over-production of food products together with over-production of forest products have caused us to change our plans of national economy. Regulation of lumber production to suit the national requirements must follow the pioneering of the last virgin forest resources of the Northwest.

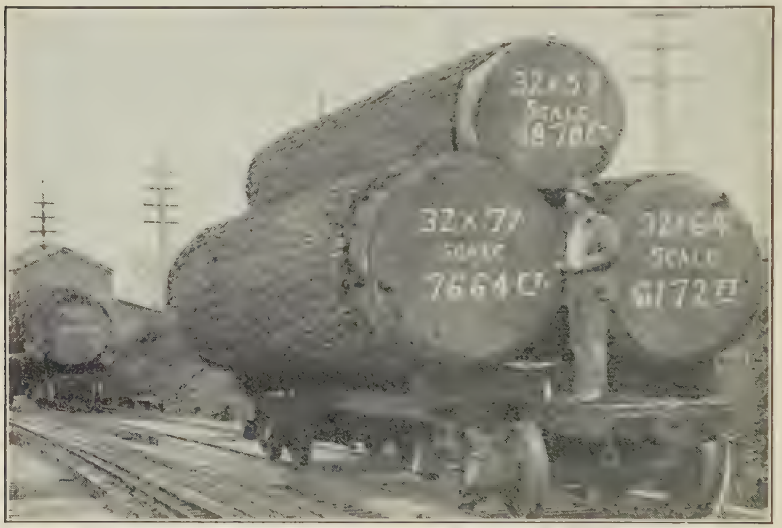


FIG. 27.—The finest and largest logs come from the huge forests of the Pacific slope. Four Douglas fir logs, all 32′ long and varying in diameter at the small end from 57″ to 90″. The logs contain from 4,870 to 14,320 b. f. each.

Present per capita consumption has decreased about 50% since 1907. Annual lumber production has decreased from 46 billion b. f. in 1907 to 10½ billion in 1932 and has since risen to 20 billion feet.

There will always be a lumber industry. It is a natural and most important outlet for the products of the forest and yet lumber represents only one-half the total wood volume cut each year. Consolidation of the lumber industry and more efficient utilization must follow the pioneering stages. Our lumber-producing capacity is more than twice the needed annual consumption requirements. The small mill has largely replaced the big sawmill east of the Rocky Mountains. One of the most romantic and interesting chapters in American history has been associated with the pioneering lumber industry. The stories of Paul Bunyan and his superhuman exploits have constituted some of the best of our American folk-lore.

With the regrowth of timber, efficient protection from fire and other injurious agencies, such as insects and fungi, stabilization of employment and community life have succeeded the former nomadic practice of building great sawmills, which disappeared with equal rapidity. Along one railroad line in western Louisiana, some twenty-three sawmills, each cutting over 100,000 b. f. per day, went out of existence within five years. Prosperous and happy communities disappeared; railroads were left without lumber freight to haul; banks, churches, and libraries disappeared; and a few dismantled and unused homes were all that remained in the tragic story. Vast cut-over forests, too often burned, were all that remained of a once valuable virgin forest. Today the United States Forest Service and various federal agencies, as well as many private companies, are acquiring, protecting, planting, or otherwise caring for these " desert lands " in the South, the Lake States, and the Far West in order to change these unfortunate conditions and bring back the growth of timber. Thus, they hope, small permanent communities will replace the " boom and bust " days of previous years.

Forestry and Community Stabilization

There is a definite interdependence of forests and the permanence of communities. During the expansion periods in the development of the nation, there were many booms in lumbering, agriculture, grazing, mining, etc., in many parts of the Middle and Far West. The boom period generally meant excessively rapid exploitation and liquidation of resources, followed by their exhaustion and ultimately the complete abandonment of many villages and settlements. So-called " ghost towns " are found in many mountain towns of the West, where mines were quickly developed, exhausted, and then abandoned. There have been many booms in the development of orchards

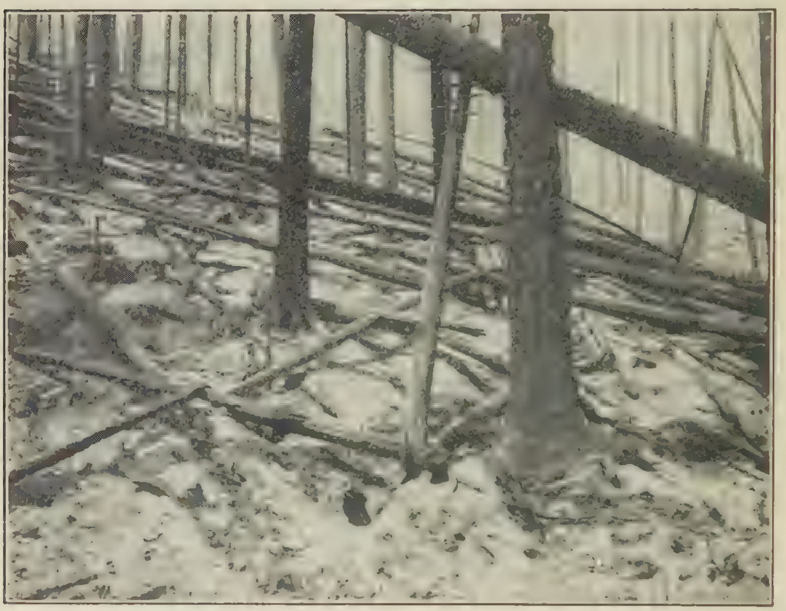


Fig. 28.—A fire-killed forest in Montana. Fires mean loss of employment and, therefore, payrolls as well as loss of taxable property and the resultant profits that may accrue from the conversion of standing timber into lumber and other useful commodities. There is no hunting or fishing or other recreational possibilities for enjoyment by the people when our forests are destroyed by fire.

and farms, and of real estate in the West, East, and South. Similarly there have been " cut out and get out " and " boom and bust " towns in the cutting of our virgin timber in the Lake States and in the South.

The most serious abuse and lack of foresight in handling of forest resources have been found in the upper part of the lower peninsula of Michigan. As long as virgin timber resources were available, prosperous communities were built about the logging and sawmill activities of the region. Railroads were built, farms developed, and a happy civilization ensued. The peak of prosperity and activity was reached about 1890. Attempts were then made to colonize the cut-over lands with farms. The soil proved too sandy, sterile, and barren. With the abandonment of sawmills the source of wages vanished, and people gradually left these communities. Schools and roads were left unused. Taxes increased. Within a few more decades, this became a deserted region with scarcely enough business prosperity, agriculture, and activity to maintain the schools, roads, railroads, and other transportation facilities.

Similar booms have been found in various parts of the Lake States, the Appalachian region, and in parts of the South. Supplanting this era of boom cycles has come a new realization that community stabilization is intimately related to sustained yield management of our forests, whereby the industrial capacity is equal to but not greater than the growth capacity of the forests.

With this principle in mind, many forest industry communities are becoming gradually stabilized to make them permanent and more prosperous. Examples of such development in this country are: Gray's Harbor, Washington (Hoquiam and Aberdeen); Bogalusa, Louisiana; Brewton, Alabama; Cloquet, Minnesota; Tupper Lake, New York; Fargo, Georgia; Kingsport, Tennessee; Winchenden, Massachusetts; Longview, Washington; Crossett, Arkansas; Canton, North Carolina; Rumford, Maine; and Laurel, Mississippi. Many others could be mentioned.

It must be understood that the industries in those communities do not necessarily own or control the forests in their vicinities, but the consumptive capacities of these industries are practically equivalent to the volume growth of the forests. Standing timber may be partially controlled by some of these industries; others purchase their wood requirements in the open log market. Some of the communities are " one industry " towns while others are widely diversified. Winchenden is a great chair and furniture center; Longview is the greatest lumber-manufacturing center; Kingsport has such widely diversified industries as a pulp mill, hardwood distillation plant, and sawmills. Crossett and Bogalusa have large pulp mills, sawmills, and timber preservation plants. Brewton has a large sawmill, turpentine still, veneer and box board mills and creosoting plant.

Sufficient supplies of raw material (timber growth) are and will probably be available to keep these industries permanently engaged. Thus community life will be stabilized and banking, commerce, trade, and the civic, religious, and educational existence dependent upon them, will be preserved.

High-Quality Versus Low-Quality Producing Areas (Commercial Versus Protection Forests)

Specially desirable areas are being selected for the practice of the more intensive and profitable forms of forestry. Good soil locations produce timber of good quality and in a short length of time. Conversely, poor sites — that is, those with thin soils and on unfavorable, rocky, and steep locations — produce trees of slow growth, limby in character, and often with misshapen trunks. Timber located near a market is much more valuable than timber growing at some distance.

Recently, surveys have been made to determine areas that will produce good timber in the least possible time and with the least expense. It is well known that lower slopes and valleys with deep, rich soils and centuries of accumulation of decayed vegetative material generally produce excellent timber. Conversely, poorer quality land is often found on upper slopes, in high, rocky regions, and on mountain tops where the soil is thin and deficient. One recalls the exceedingly poor, misshapen, and crooked specimens commonly found at high, wind-swept altitudes, compared with the tall, stately trees of the rich bottomlands. Swamps usually produce trees of slow growth and poor quality because of the excessive amounts of available water, although some species of trees will grow only under such swampy or wet-land conditions.

Second growth loblolly pine may grow an inch in diameter and perhaps from two to four feet or more in height per year on favorable soils, whereas some trees may require eighty years or more to grow an inch in diameter on soils lacking the proper nutriment and moisture. There is a wide variation in the quality of our forest soils, and recognition is being given to the better sites. More profitable and more intensive forestry can be practiced on the good soils than on the poor ones.

Commercial forests should be restricted to those areas that will grow trees quickly and of good form and quality. The Federal Government can well afford to own, protect, and maintain forests on our high and relatively inaccessible mountain slopes where soil and water conservation features, climatic influences, aesthetic values, etc., may serve mankind most usefully; but such private enterprises as lumber companies, pulp and paper corporations, and other wood-using industries which pay taxes, incur heavy maintenance expense, and pay dividends on investment must grow timber on the more favorable and accessible locations.

There may ultimately develop a rather sharp line of demarcation between the areas where forests may be profitably grown for commercial purposes, and so-called protective forests which must be maintained principally for their value for watershed protection, flood prevention, soil conservation, and recreational, aesthetic, and similar purposes.

Areas especially favorable for the practice of intensive forestry are selected on the basis of: (1) Volume of quantity production from quick-growing species. (2) High value production — white pine with a stumpage value of $10 or more per thousand b. f. is better than some species of low value. (3) Proximity to markets. Higher values and closer utilization are possible if saw logs are cheaply and quickly transported short distances to the mills. Some of the highest values and most efficient utilization are found in the planted forests along the Niobrara River in Nebraska and the small lodgepole pine on the Minidoka National Forest in Idaho. (4) Fire and injury hazard. This risk from fire, insect, or fungus damage may be a controlling factor in the selection of the best locations for forest management.

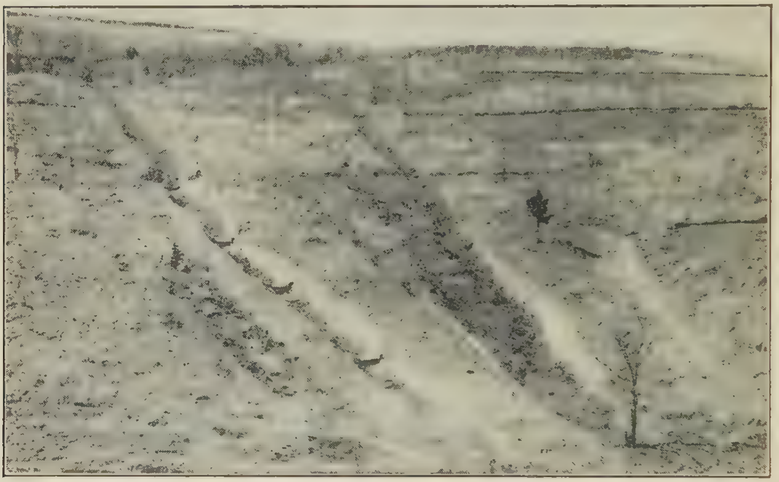


Fig. 29.—Check dams, diversion ditches, and brush matting, used to control erosion, on a 30% slope on an abandoned field in the Tennessee Valley. (Photograph by Tennessee Valley Authority.)

Thus volume and value production, marketability, and risk are the four fundamental guides in the choice of areas for the most successful practice of forestry.

Forestry and Rural Zoning

Economic conditions surrounding tax delinquency concurrently with the abandonment of farms, unsuccessful attempts to colonize cut-over timberlands, etc., which have been especially acute in Michigan, Wisconsin, and in many other parts of the country, have resulted in zoning ordinances and laws which will result in better land use and community development. The zoned areas may be devoted most profitably to forestry with its closely related recreation, game management, water conservation, or special industrial uses; whereas the better agricultural lands are set aside for tillage and to meet any demands for new farms. Heretofore no scientific approach has been made to determine the suitability of various types of soils. Much land which was cultivated has been found to be too stony, sandy, or swampy or the topography too steep for agricultural development. Rural zoning is intended to prevent the wastage of both human and financial resources on such types of land. Vast economic losses have been incurred by attempting to farm these types of land throughout New England, the Middle Atlantic States, the Lake States, and in sections of the South and West. The attempts to settle the cut-over pine lands in Michigan over a period of twenty or more years have been particularly disastrous, resulting in tragic stories of failure to colonize farms and serious economic losses.

The first zoning ordinance was enacted in 1885 in Modesto, California. Wisconsin and Michigan have made material progress in this direction. Wisconsin enacted a law for county zoning in 1923. The economic and financial problems of many of these sections have been discussed by agricultural and forestry leaders for many years. Public sentiment was gradually focused on definite legislative action. Abandoned farms were purchased under a reforestation act in New York, whereby 20 million dollars was set aside for the purchase and reforestation of one million acres.

Zoning is a form of public control of the use of private and public property in the interest of general welfare. It often applies to structures as well as to the uses of land. In Florence County, Wisconsin, a zoning map discloses that a very large share of the area is best suited for forestry and related purposes.

Only a small portion of the total area of the county is suitable for agricultural development and a still smaller area is set aside for recreational purposes. This entire subject is closely related to the whole land use and planning program which is treated elsewhere. From the chaotic conditions of tax delinquency, farm abandonment, and the rapid rise and fall of communities, there has gradually emerged a widespread movement in favor of planning and zoning for the protection, preservation, and perpetuation of our basic resources. Governmental services have taken on a new responsibility to protect the individual and the public, so that our resources in land, forests, and waters may be developed for the best welfare of the local communities as well as the public at large.

Advantages of Forestry to the Economic Welfare of the Nation

Forestry means planned economy for the fullest development and use of the forests best to serve mankind. This service is rendered in many aspects vital in the life of the nation. Among these may be briefly summarized the following:

1. Continuous and Stabilized Employment. Recent years have indicated how vital employment is to the national welfare. By maintaining an adequate and continuous forest cover, employment will be given not only to the present generation but to many generations to come.

2. Assurance of an Adequate Supply of Construction Materials. Shelter, next to food, is the most vital necessity of mankind. Although there are many substitutes for wood, we shall always require large quantities of wood for our people.

3. Supplying of Materials for Industrial Usage. As indicated elsewhere, there is a vast array of forest products and uses aside from materials of construction.

4. Maintenance and Stabilization of Business and Community Life. In many states in our important forest regions, trade, banking, transportation, and employment, etc., are inextricably related to forest activities. Prosperous and stable

community life will be assured in a plan of sustained forest management.

5. **Development and Maintenance of a Profitable Export Trade.** If our forests are properly protected, managed, and used, we probably shall have an excess supply which may be the source of a very extensive and profitable export trade. This country is the most important lumber-producing and lumber-using nation in the world. It is far better for the national economy to export than to import lumber and wood products. A favorable balance of trade will inure most satisfactorily to the economic welfare of the nation.

6. **Miscellaneous Services.** Many other economic benefits of forestry could be mentioned, such as the perpetuation of our hydro-electric, irrigation, grazing, mineral, and recreational industries and activities dependent upon the forest. The recreation industry is a vitally important one in Maine, New Hampshire, Vermont, and the Adirondack and Catskill regions of New York. Provision for health, recreation, and vacationing for enjoyment constitute one of the great industries of the country. Switzerland derives an important share of its revenues from its attractive features for tourists, vacationists, and those seeking health and outdoor recreation. Thus, many phases of forestry are intimately dependent upon the forest, the direct and indirect benefits of which may be measured in many millions of dollars. Timber and other products cannot be measured in terms of commercial values.

Deterrents and Obstacles to the Practice of Private Forestry

There are many difficulties in the practice of private forestry. It is a business of growing trees and forests for profit. A large part of our forests is owned by private individuals or corporations. Many factors tend to discourage or prevent the practice of forestry on private timber properties. It requires many years to grow trees. One looks forward many years, even generations, to the results of present efforts in planting, growing, and maintaining a proper forest cover. Such continuous and stable forms of public ownership as that of state, county, federal, and municipal governments have a great advantage in practicing forestry because they do not have to pay taxes and they may wait for years for both direct and indirect returns. Furthermore, indirect benefits that may not be measured in monetary returns are secured in public ownership. Private individuals and business corporations cannot afford to wait many years for financial profits. The most serious difficulties of private forestry are:

1. **Danger of Fire and Pest Injury.** The costs of protection from fire are exceedingly burdensome in some regions of severe fire hazard. Damage from fire, insects, and fungi have forced immediate cutting of some timber tracts. Perhaps forest fire insurance may assist owners to practice forestry, but as yet no satisfactory system has been devised and adopted.

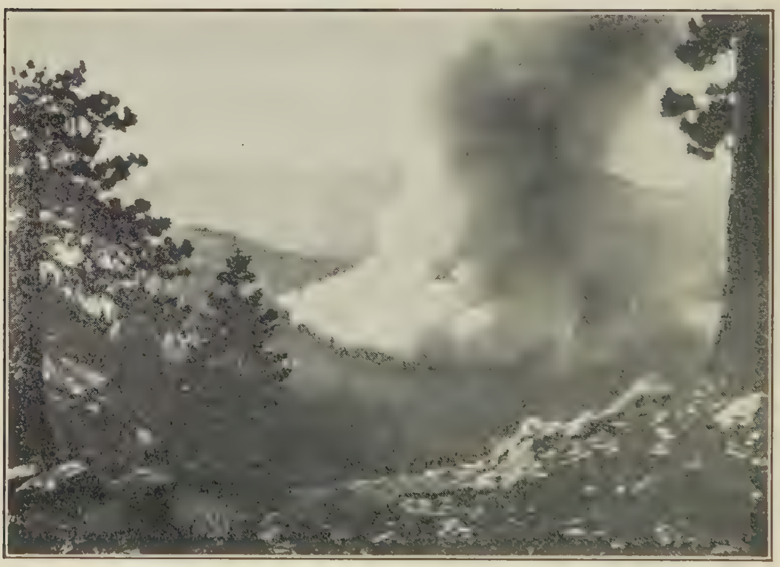


FIG. 30.—A crown fire gaining rapid headway in the Sierra Mountains of California.

2. **Taxation.** Trees require many years to mature. Property taxes have not been properly adjusted to making forestry a successful business venture for private enterprise. Government and state forestry do not necessarily have to show a profit in the value of timber marketed, grazing, water, mining, or other rights sold to individuals or other forms of profitable business. Some forests may have their highest utilitarian value as protection forests. Some states, as Wisconsin, Oregon, Louisiana, Indiana, and New York, have exempted taxes in an effort to encourage the practice of forestry.

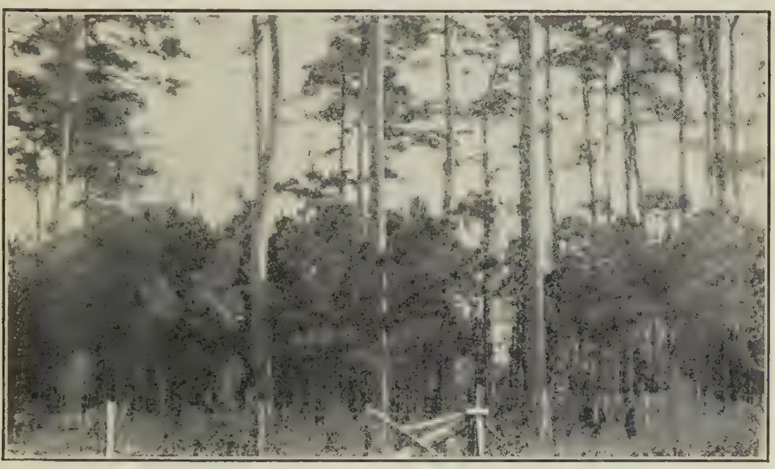


FIG. 31.—Typical two-storied forest of loblolly pine in South Carolina. The understory is 10 years old and the upperstory, or overwood, is 40 years old.

3. **Interest on Capital Investment.** Cumulative interest charges, together with depreciation of equipment and improvements, may constitute a very heavy burden, financially, on forest properties. Private individuals and companies must pay taxes and heavy interest charges. Federal and state ownership means freedom from responsibility of interest and to some extent of depreciation charges. Much timber in the Northwest is being liquidated because the burdensome interest charges prevent its being carried until a time when this timber may be cut and merchandised in a more orderly and economical manner.

4. **Unsatisfactory Prices for Forest Products.** Forestry is a business enterprise and, if the prices for the products are sufficiently high, timber may be grown profitably on an intensive basis. Prices are still relatively low for many forms of forest products. High prices mean intensive forestry and low prices, conversely, mean extensive forestry and great wastage of timber supplies. A greater volume of the trees now being cut is wasted than is finally utilized. If market prices were sufficiently attractive there would be little if any waste. Furthermore, the price range of forest products varies considerably. Unstable prices frequently discourage the practice of forestry on many properties.

5. **Public and Private Apathy.** The public is still generally unaware of the manifold direct and indirect benefits accruing from the practice of forestry. Forestry has such wide-reaching public benefits that some form of subsidy or assistance should be extended to private owners to make possible the practice of successful forest management. The borrowing power of state and federal governments at low rates of interest could very well be extended to encourage private individuals, as farmers and industrial organizations, to practice forestry, not only for the direct benefits secured to the owners but for the great number of benefits that accrue to the general public.

Costs of Holding Timberlands

For many years its has been a traditional policy of many forest industries to acquire and protect sufficient holdings to assure an adequate supply of raw materials for the future and justify and protect the large capital expenditures for initial plant construction and equipment. This policy of acquiring large timber reserves to protect the future of capital investments is changing. It is becoming recognized that second growth timber is renewing itself at a rapid rate. Many forest industries are now planning to purchase their log or raw material requirements in the open market rather than indulge in expensive overhead incident to holding expensive timber properties for a long period of time. Examples of this may be seen at Kingsport, Tennessee, many pulp and paper mills, sawmills, and other industries in all parts of the country. Only a few railroads have maintained forests to protect the future of their cross tie supply in spite of the fact that from 50,000,000 to 100,000,000 cross ties have been purchased each year. Many sawmills located at tidewater in the Pacific Northwest do not own any standing timber but purchase rafts of logs in the open market.

Costs of holding timberlands include expenses for administration, interest on money borrowed to purchase the original area, fire, and other protection expenses, and finally taxes. So-called timber bonds have not been received generally by the public or bankers as a very attractive form of investment because of the hazards of holding timberlands. The expenses for administration are generally small when chargeable to each 1000 b. f. or cord of wood that may come off the tract. However, expenses for interest on indebtedness represent about 60% of the costs of holding timberlands. Taxes represent about 38% and fire protection about 2%.

Fig. 32.—Some of the most dense and largest timber stands to be found in the world are located on the Pacific Coast. This shows a typical virgin forest of Douglas fir and some other species at Ryderwood, Washington. Some of these trees are from 3′ to 6′ or more in diameter at the base. Anticipated rise in stumpage values has not been realized during the past decade in this region.

When standing timber is converted into lumber or pulpwood it must be relied upon to meet these heavy carrying charges. Based upon the average of recent ten year production, these carrying costs chargeable to lumber production per 1000′ have been $4.01. In other words, all lumber used by the public is chargeable with $4.01 per 1000 b. f. for these overhead costs of carrying timberlands.

The Farm Woodland and Its Importance

About 25% of all the commercial forest land, or 127 million acres, were found (1930) in farm woodlands which generally vary from a small lot of 5 to 10 acres up to 200 or more. Since the recent abandonment of farm lands to forest, estimated to be about 58 million acres, this area in farm land has increased to approximately 185 million acres. About 95% of the total acreage of farm woodlands is found east of the Rocky Mountains. In the Central States it forms about one-half of all the forests and in the South, Northeast, and Lake States, about one-third of the commercial forests.

The farm woodland, therefore, is very important in our plan of forest economy. It generally lies close to or within the regions of important wood consumption and therefore enjoys stumpage values which are greater than those of woodlands located in remote and inaccessible regions.

The number of our farms has remained about stable, at 6½ million, since 1930. Before this date, for about 20 years, the number of farms had increased at the rate of 90,000 yearly. The peak of farm expansion was reached in 1910. There has been a distinct tendency toward smaller sized farms, especially in the East and South, and a concurrent increase in the area of woodlands because of the abandonment of cleared lands and their resultant reversion to forest. An area about twice the size of Ohio has thus become available for forest use. The average farm requires about 50,000 b. f. for home, barn, and miscellaneous construction and therefore is an important user of lumber.

Generally the farm forests produce only a small share of their potential capacity. Fire, unregulated grazing, and the cutting of small and immature trees are the three great causes of low production. Unregulated grazing in the Central States and fire in the South have proved especially harmful, although both have caused some damage in all regions.

The chief products of farm woodlands are: (1) fuelwood, (2) fence posts, (3) saw logs, (4) farm construction timbers, planking, bridging, etc., and (5) source of supply for the local lumber markets. These woodlands are locally of vast importance as a source of pulpwood, especially in the South, Lake States, and Northeast, railroad cross ties in all regions except the West, veneer logs in the Central States and South, naval stores in the South, and poles and piling in some sections of the East and South. The value of all forest products cut from farm woodlots in a recent year was over $240,000,000. The forest products constitute an important source of the farm cash income. Many mortgages and carrying charges have been paid by the net quick assets secured from farm products.

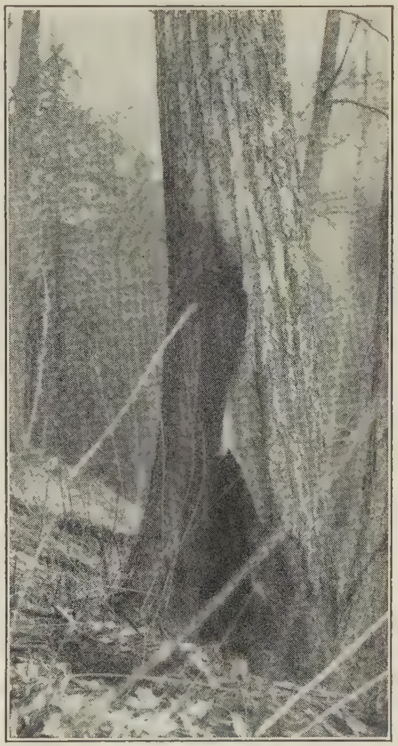


FIG. 33.—Results of repeated burning at the base of a chestnut tree in Tennessee. Trees weakened in this way are easily wind-thrown and more readily attacked by fungi and insects. Farm woodlands have suffered much from fires.

These woodlands offer one of the best opportunities for sustained yield. Generally they are cut on a rough form of selection system. Selective logging has been unintentionally practiced for many years. Usually, very unscientific methods have been pursued on these second growth timber tracts. The best trees and the best species are generally cut first so that the future forests are left to grow up from a cull forest composed of inferior species and the poor specimens. These woodlands are often cut when growing at the most favorable rate of wood increment. The trend toward purchase of logs in the open market by local sawmills, made possible by the motor truck, is tending toward better selective logging because only the trees of the largest and most profitable size are cut and the remainder is left to grow up for the future. Woodlands, like money in the bank, are producing an annual increment similar to the interest accumulating on savings deposits.

Concentrations and Possible Monopolies of Private Timber Ownership

For several years it was felt that there were great lumber trusts or monopolies with dangerous concentrations of timber ownership in relatively few hands. This search for monopoly and timber ownership did not indicate that there were any concentrations in ownership which are detrimental to the best interests of the general public. Within recent years, concurrently, with decreasing stumpage values, the tendency has been to break up the larger timber holdings through forced sales or to liquidate investments by cutting the timber at an increasing rate. Competitive conditions have been very severe in the lumber industry for 20 years or more. The industry has been faced for many years with two great problems — either to secure a higher price for the product or to reduce costs of logging and manufacture. Both were attempted. But it was found that with lumber production scattered among 30,000 sawmills throughout the country it was impossible to regulate prices or to liquidate timber assets on a satisfactory price basis. When prices became attractive, night shifts were added to day work, additional mills came into production, and the surplus lumber was quickly dumped on the competitive market at reduced prices. The peak of lumber prices was reached in 1920. Since then there has been a lowering of both stumpage and lumber values. At the present time, there is no justified fear of a monopolistic control of the timber resources of the country in relatively few hands.

Output (supply) can be readily regulated in some industries, as in steel and automobiles, so that the price structure of the product is protected. Production is from relatively few plants and supply can readily be adjusted to the public demand. But in the timber industries, there are 30,000 or more sawmills, and many more producing units of various other commodities. Under these conditions it is practically impossible to adjust supply to demand. Consequently, competition is keen for all available business, prices rise and fall rapidly, and chronic overproduction is the common practice. Therefore, there is little likelihood of any monopolistic control of our resources.

Forestry Integrated with Our Internal Development

Forestry must not be considered as a separate activity or objective. It is closely related to agriculture and to the furnishing of materials for our great industries, notably the automobile, construction, railroad, and other transportation facilities, ship-building, furniture, wood-working, and similar activities. It embraces the protection of our navigable streams. It contemplates the prevention of floods and erosion, the preservation of aesthetic values, protection from winds, storms, and drifting sands, a home for fish and game. Closely integrated with our unequaled timber resources have developed great industrial plants and commercial enterprises of great magnitude. Measured in terms of capital invested, in numbers of gainfully employed men, in the value of the products, and in importance to our national welfare, these activities are found in the forefront of our national prosperity and welfare. Much of our banking, our export commerce, the freight hauled by our railroads and motor trucks, and even the automobile industry are directly dependent upon an assured future supply of wood products. Our railroads could not operate without cross ties. Docks and wharves could not be built without piling. Forest products furnish an important part of the freight hauled on our transportation systems. Banks are dependent upon timber industries in many sections of the South and West Coast. Employment is furnished by timber industries to several million men in many parts of the country.

Originally, under primeval forest conditions, wood was the only fuel. Logs were used for dwellings. Wood entered almost every phase of human welfare and activity, either for shelter, warmth, cooking, or employment. It has been said that from the cradle to the grave our lives are inseparably associated with wood.

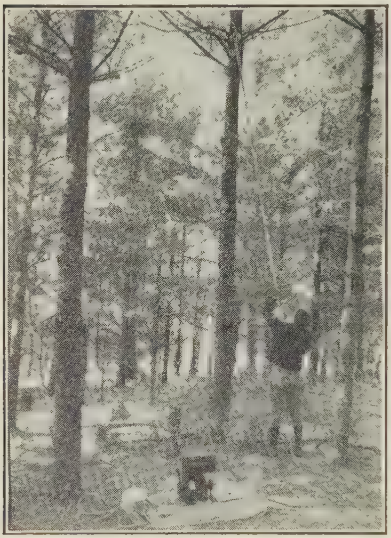


FIG. 34.—Mechanical pruning saw which permits cutting of limbs flush with the tree stem to 17′ or the height of the first log. This has been very successfully used in several parts of the country. If trees are pruned when 4″ in diameter, lumber values may be increased by $100 or more per acre.

Our great timber, steel and iron, cement, and textile industries are all dependent upon wood for at least part of their existence. Still later, the automobile, machinery, and almost every other industrial enterprise depend upon wood, at least for shipping purposes. Boxes and crates normally require about 15% of our total lumber production.

Eras in the Development of American Forestry

One may review in retrospect the development of American forestry and separate it into three distinct and outstanding periods as follows:

1. **Exploitation Period from the Earliest Settlements to 1891.** The people of this country have for many generations during this period taken for granted the vast and rich heritage of nature's resources that have proved to be the bulwark of strength and the backbone of our prosperity. With the increasing population and westward expansion, forests and other resources were exploited with little if any thought of the future. Our resources were considered inexhaustible. It was natural, perhaps, that with such abundant and low-value resources little thought was given to the future. This period of exploitation took place with respect to our agricultural soils and forests as well as our forage and grazing resources and our minerals. The spirit of exploitation, as opposed to conservation, was widespread. Lands, waters, and forests were almost free for occupancy and use and generally were badly mismanaged by both public and private agencies.

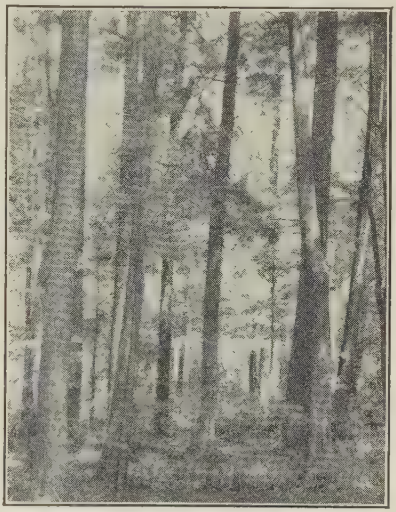


FIG. 35.—A mixed forest of virgin hemlock, beech, oak, and some other hardwoods in the forests of northwestern Pennsylvania.

2. **Reservation and Organization Period from 1891 to 1933.** In 1891, the first National Forests were set aside. Forthwith came a rapid succession of withdrawals of Public Domain for various benefits to mankind. More than one-fifth of this great domain was reserved for National Forests, National Parks, Indian Reservations, mineral lands, reclamation projects, and similar services to benefit the people of the country, espe-

cially in the West. Conservation definitely replaced the spirit of exploitation.

Although much progress was made in the development of forestry technique through research and improved organization and a gradually increasing personnel of trained foresters, this period is chiefly marked by expansion of areas for public forests and parks. This was also the period of great development in forestry education and research. The basic foundation was laid for later intensive development and improvements under the Rooseveltian conservation régime.

3. **Period of Active Timberland Management and Development Beginning with 1933.** For the first time in the history of American conservation, large numbers of men in the Civilian Conservation Corps (from 300,000 to 400,000 or more) became available for the development, improvement, salvaging, and protection of our vast resources which had been set aside as National Forests, National Parks, and state forests and parks. This constituted the first great contributions to the consolidation and effectiveness of the national conservation program. Concurrently with this policy came an expansion in the areas of both federal and state forests and parks and intensive development of road construction, improvement of facilities for the detection, prevention, and control of forest fires and other injurious agencies such as insects and diseases. Most of the camps of the Civilian Conservation Corps were located

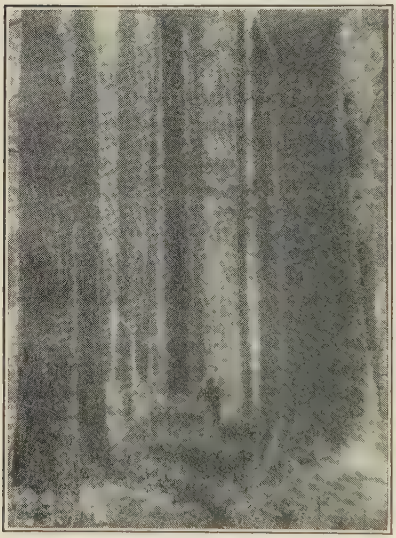
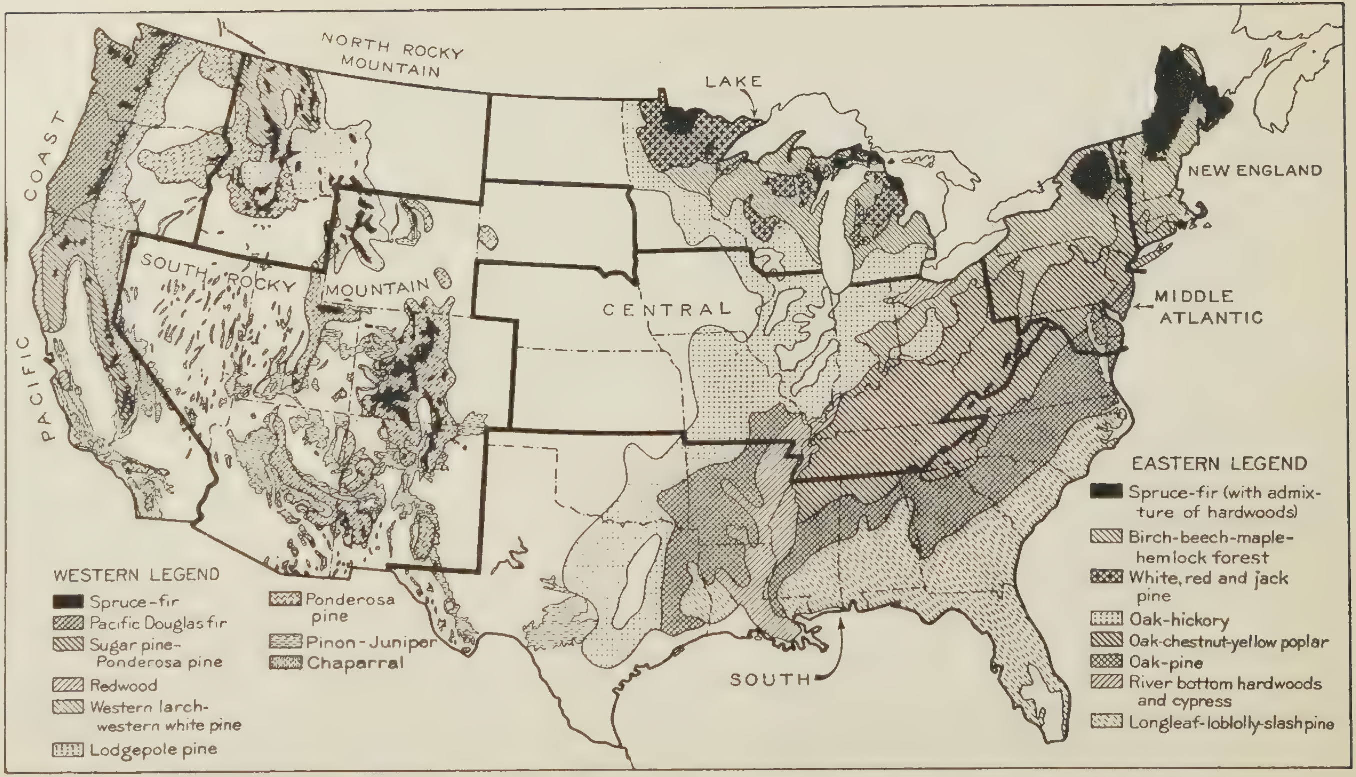


FIG. 36.—Unusually dense stand of mature Sitka spruce seen at Bond Bay in the Tongass National Forest of Alaska.

on the National Forests. These forests had received inadequate support and altogether were poorly manned and developed. This new program made it possible to improve the character of the timber stands, to plant hundreds of millions of trees, to construct horse and foot trails, bridges, telephone lines, lookout towers, and to provide recreational facilities for camping and picnicking and for hunting and fishing. Vast areas of eroded lands were salvaged for the future, many thousands of acres of range lands were improved, and the wildlife protected, encouraged, and developed. Concurrent with this program came a great expansion in federal activities which had a direct bearing on forest conservation, particularly the Soil Conservation Service, Tennessee Valley Authority, the Biological Survey, and more intensive development of facilities in our state forests and parks.



Forest regions and principal types of forests found in the United States. After U. S. Forest Service.

CHAPTER III

FOREST RESOURCES, OWNERSHIP, AREAS, AND VOLUME OF STANDING TIMBER

General

When the Pilgrims came to Plymouth, the Cavaliers to Jamestown, and the Dutch to Manhattan Island, they found a rich and abundant primeval forest extending from the Atlantic to the treeless plains of the Middle West. Originally the forests occupied nearly one-half the total land surface of the country, or about 822 million acres. Today, about one-fourth of the area of the country, or 500 million acres, is covered with timber, of which about two-fifths are virgin or uncut timber. Much of it is found at high elevations in the mountains or in the swamps or on steep slopes, where it may never reach commercial size, or be of any merchantable value. Considering all potential forest lands, there are about 600 million acres classified as such.

FIG. 37.—A giant yellow poplar tree in the Southern Appalachian Mountains. (Photograph by National Park Service.)

Our forests may be divided between the eastern and western. The western forests are almost entirely coniferous, whereas both conifers and hardwoods are found in the eastern forests. The Forest Service divided the timberland of the country into a number of regions, with types for each region.

Areas

Timberlands cover about one-fourth the area of the country, or 5 million acres of which 188 million acres contain merchantable saw timber. One-half the area of saw timber is virgin or old growth. The largest forest area is found in the Southeast which contains 39% of all the timberlands and consists largely of southern pine. The Pacific Coast has 13½% of the area, but this relatively small portion contains the big bulk of the standing timber, because of the enormous size of the trees and density of the forests. Only 26% of our forest area is found west of the Great Plains, the remainder, or 74%, being found east of the Plains.

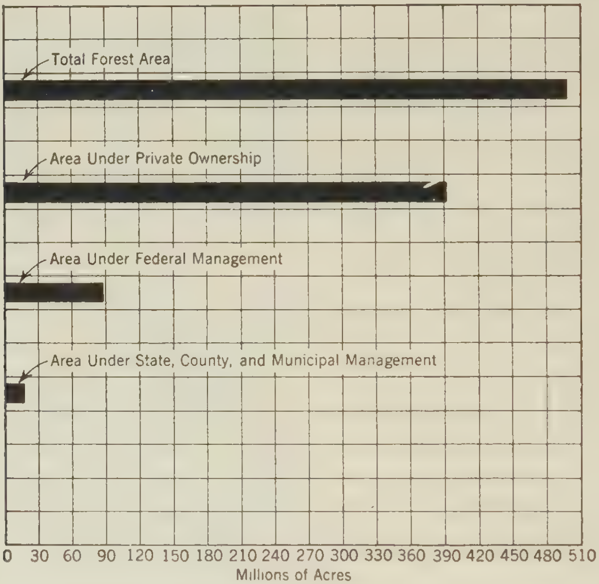
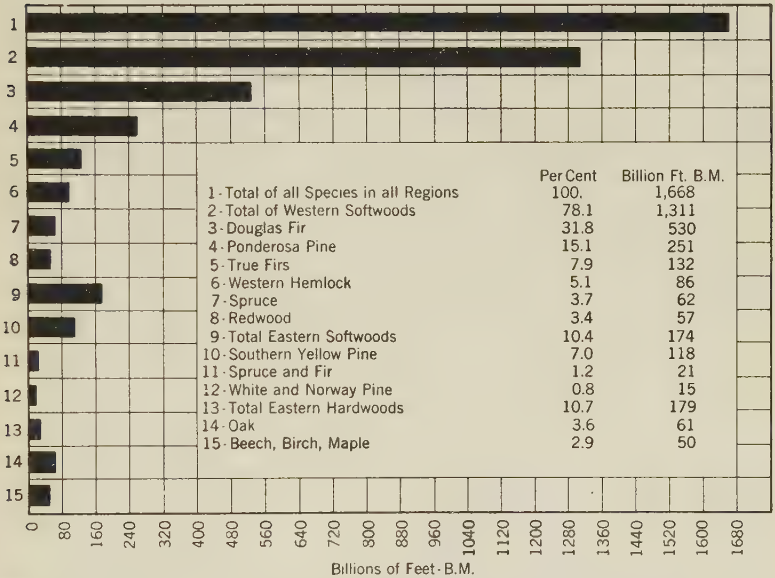


Fig. 38—Forest areas by classes of ownership.

Ownership

Our forests are classified as to ownership into (1) private, (2) federal, and (3) other public agencies such as state, county, and municipal agencies. Private organizations, lumber companies, pulp and paper companies, farmers, hunting and fishing clubs, etc., own 79% of the total forest area. Some individual companies own from 100,000 to several million acres of timberland. If forestry is to be successfully practiced in this country, we must look to the private owners as well as to the public agencies, because the former own the big bulk of the timberland both in area and volume. Federal agencies, particularly the Forest Service, the National Park Service, Indian Service, and the War Department, own and manage 18% of our forest area. Most of this is in National Forests found particularly in the Rocky Mountains and in the Pacific Coast States. In



	Per Cent	Billion Ft. B.M.
1-Total of all Species in all Regions	100.	1,668
2-Total of Western Softwoods	78.1	1,311
3-Douglas Fir	31.8	530
4-Ponderosa Pine	15.1	251
5-True Firs	7.9	132
6-Western Hemlock	5.1	86
7-Spruce	3.7	62
8-Redwood	3.4	57
9-Total Eastern Softwoods	10.4	174
10-Southern Yellow Pine	7.0	118
11-Spruce and Fir	1.2	21
12-White and Norway Pine	0.8	15
13-Total Eastern Hardwoods	10.7	179
14-Oak	3.6	61
15-Beech, Birch, Maple	2.9	50

FIG. 39—Stands of saw timber by principal species and groups of softwoods and hardwoods.

some states, as California, Idaho, Montana, and Oregon, a large share of the forest area is found within the National Forests. The individual states, counties, cities, and villages own only 3% of our forest area.

There has been a pronounced expansion in the acquisition of forest areas by the public agencies since the World War and notably since 1933. More than 30 states now own and operate forests, and many counties and municipalities have purchased forest lands for parks, watershed protection, recreational areas, and for growing timber on a commercial basis. New York and Pennsylvania each have more than 2 million acres set aside in their state forests and parks. Of the 188 million acres of saw timber, 126 million are owned by private individuals or companies, 59 million are owned by federal agencies, and the remainder of 3 million are owned by the states and local communities, as cities, villages, and counties.

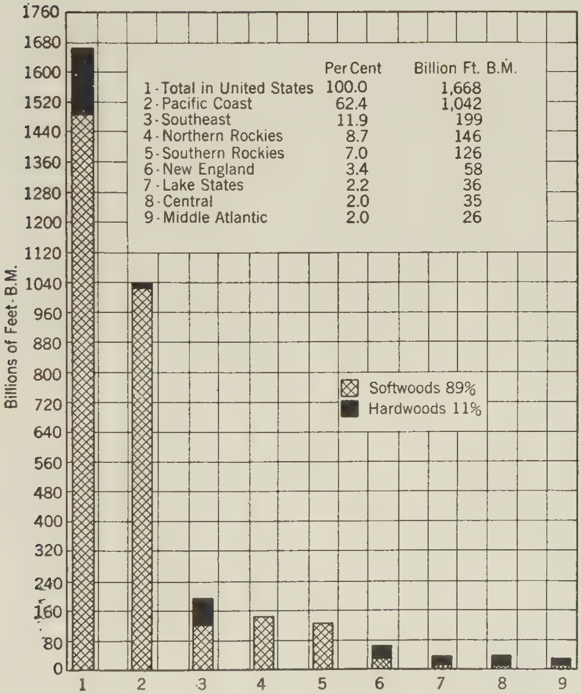
In the West, public ownership represents 65% of the total; in the East only 4% is represented in federal, state, county, and city ownership.

Volume of Standing Timber

The total standing timber amounts to 1667 billion b. f., or about one-third the original stand. Eighty percent of this is virgin or primeval growth. At the normal rate of cutting, assuming no further losses by fire or pest injury, the present stand would last about 74 years.

Of the total volume, 89% consists of softwoods and 11% of hardwoods or broadleaf trees. The region west of the Great Plains contains 79% of all the remaining saw timber. The three Pacific Coast States contain 62%. About 90% of all the softwood saw timber is found in the West and only 10% in the East. Oregon contains more standing timber than any other state. Washington ranks second and California third in standing timber. The entire eastern forests contain only 21% of the standing saw timber. The principal species still found in our saw timber forests in order of importance are:

Species	Percentage of Total Volume
Douglas fir	31.8
Ponderosa pine	16.1
True firs	7.9
Southern yellow pine	7.0
Western hemlock	5.1
Western spruce	3.7
Oak	3.6
Redwood	3.4
Birch, beech and maple together	2.9
Lodgepole pine	2.6
Miscellaneous	15.9
Total	100.0



	Per Cent	Billion Ft. B.M.
1 - Total in United States	100.0	1,668
2 - Pacific Coast	62.4	1,042
3 - Southeast	11.9	199
4 - Northern Rockies	8.7	146
5 - Southern Rockies	7.0	126
6 - New England	3.4	58
7 - Lake States	2.2	36
8 - Central	2.0	35
9 - Middle Atlantic	2.0	26

FIG. 40—Volume of saw timber stands found in the various regions.

Thus two species, Douglas fir and ponderosa pine, comprise about one-half of all the remaining standing saw timber in this country. Four make up 63% of the total.

There are about 60 commercially important species found in the country but there are over 700 recognized separate species. Douglas fir and southern yellow pine represent about 60% of all the lumber used annually in our lumber markets. Some species which have future possibilities are not cut to any large extent because they are not considered sufficiently valuable and useful, such, for example, as western larch, western true firs, tupelo and black gum, and some of the minor hardwoods.

Fig. 41.—Selway River, Selway National Forest, Idaho.

Depletion of Forests

The possibility of a timber famine has been widely discussed. Only recently has a careful analysis been made of the annual growth and cut of timber in this country. The Forest Service estimated that there is an annual consumption of about 14 billion cubic feet including cutting for commercial purposes and losses by fire, insects, disease, windfall, etc. The annual growth is about 9 billion cubic feet. However, the above figure of depletion is based upon years of large consumption; namely those prior to 1930. Lumber production dropped from 38 billion b. f. normally (1926 to 1929 inclusive) to about 10 billion b. f. in 1932. The present annual drain of forest products is about 4 billion cubic feet for lumber, 4 billion for other forms of forest products, and about 2 billion lost by fire and other natural or pest agencies; a total of about 10 billion cubic feet. If current fire, insect, and diseases losses are reduced one-half and timber growth increased by cultural thinnings, planting, etc., it would be possible to produce annually about 19 billion cubic feet. Therefore there is little likelihood of a serious timber famine or even of a dangerous economic drain for commercial purposes if a forestry program is properly coordinated and put into effect. There is a present reserve of standing saw timber of over 1600 billion b. f. which is equiva-

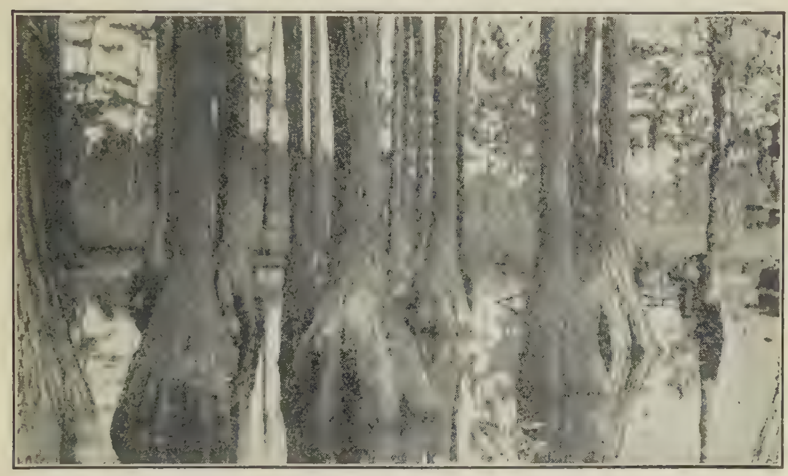


Fig. 42.—A typical swamp scene in Louisiana where the forest is composed of cypress, tupelo, and red maple. The crowns are festooned with Spanish moss which adds a delightful phase to the beauty of these forests.

lent at the present rate of utilization to 74 years supply. It is estimated that our southern pine forests are growing much faster than they are being cut. Douglas fir and other timber of the Northwest is growing about as fast as cut; but virgin conditions prevail there where decay about equals growth.

CHAPTER IV

THE TREE — FUNCTIONS AND CHARACTERISTICS

Definition

A tree is a plant with a single woody trunk that does not branch for some distance above the ground.

Even if 20 or more feet in height, a plant that branches directly at the ground is considered a shrub, although some plants that are shrub-like in the northern part of their range attain tree form in the southern part, owing to a longer growing season, greater precipitation, etc.

Part and Functions

A tree is composed of roots, trunk or stem, branches, leaves, flowers, fruit, and seed.

Roots. The roots are of two kinds, surface and tap, depending on their shape and depth of penetration. The surface roots, as their name implies, run along under the ground; the tap roots strike almost directly down and in deep soils may attain great length. 2 kin 1/surfa 2/Tap

Of the tap-rooted species, walnut, hickory, and oak are the most prominent eastern species; longleaf and ponderosa pine are the most notable of the southern and western species. Spruce, birch, elm, western larch, lodgepole pine, and hemlock are surface-rooted species. Other trees, like cottonwood and red gum, may develop a combination system with either the surface or tap root more developed, depending on the nature of the site.

The root habit of a species has an important bearing on the system of forest management which can be used. For instance, a heavy thinning in eastern spruce or lodgepole pine is attended with danger, since, owing to the shallow root systems of these species, windfall is likely to follow.

The roots serve to anchor the tree, and at the same time supply it with food materials. The absorptive parts of the roots, the root hairs, are located just back of the growing point, and the older and larger parts merely anchor the tree and transmit the nutrient solutions, the " raw sap," taken in by the root hairs. The soluble salts in the soil are taken in through the cell walls of the root hairs and are carried up through the vessels and tracheids of the sapwood. The reason for the rise of the sap is as yet not clearly understood, being variously ascribed to osmotic forces, atmospheric pressure, the action of the living cell, and the suction of transpiration, with none of these hypotheses clearly proved.

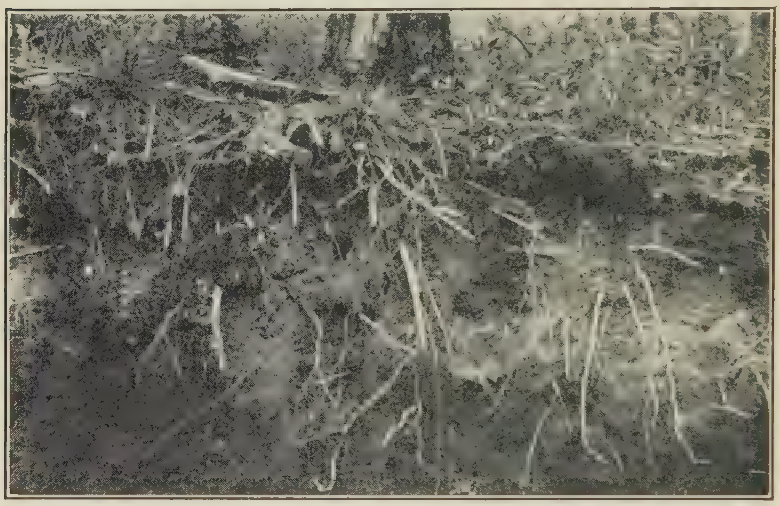


Fig. 43.—Cross-section of typical soil layers with root systems penetrating to considerable depths to hold the soil and prevent erosion. On the forest floor is a litter of leaves, twigs, grasses, and a miscellaneous accumulation. Gradually these become decomposed and form humus which serves to fertilize root systems and increase the rate of tree growth. Gradually the humus merges into the mineral soil below.

Root growth is greater in poor than in good soil, and root extension is greater in a dry than in a wet season, for the reason that the roots, under adverse circumstances, must seek further to provide the proper amount of food.

Stem. The stem is composed of inner and outer bark, heartwood, sapwood, and pith. Increase in diameter is achieved by means of the cambium layer, which lays on a ring each year. Occasionally, when the growth of the tree has been checked in midsummer, owing to drought or defoliation, an extra ring may be added. The false rings are fainter and more or less irregular, and are generally easy to detect.

The heartwood is located in the center of the trunk and consists of more or less inert material whose chief function is to strengthen and stiffen the trunk. It does not transmit any of the sap either up or down the tree, which may be proved by examining some of the hollow trees so common in our pastures. Such trees live for years with the heartwood completely rotted away, but if the cambium and sapwood were interrupted by a deep cut, as in "girdling," the course of the elaborated and raw

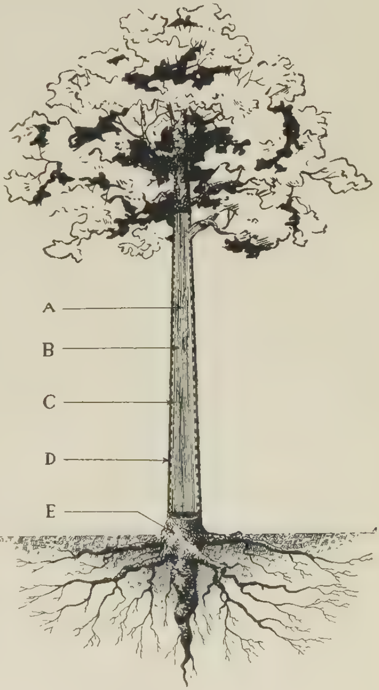


FIG. 44.—How a tree grows. The buds, root tips, and cambium layer are the growing parts of the tree. Leaves manufacture food for the growing processes, water containing minerals in solution is absorbed by the roots, carried up through the sapwood to the leaves, and there combined with carbon from the air to make food. This food is carried by the inner bark to all growing parts of the tree, including roots. *A* shows heartwood which furnishes strength and support to the tree but is inactive. *B* shows sapwood (xylem) which carries sap from the roots to the leaves. *C* is the cambium layer of cells between the sapwood and inner bark where diameter growth occurs. It builds tissues of wood inside and bark outside. *D* is inner bark (phloem) which carries food made in the leaves down to the branches, trunk, and roots. *E* is outer bark which serves as protection from injuries.

sap would be interrupted and death would almost immediately ensue. In certain species there is a limited amount of interchange between the heartwood and sapwood, but for the most part it is the sapwood alone which is alive and which transmits the nutrient solutions from the soil to the leaves.

The function of the bark is to distribute elaborated food and to protect the trunk. Like the trunk, it adds a ring each year. The rings are much flattened by pressure, and are hard to detect.

Leaves. The leaves are the factories of the tree to which the thin watery solutions are carried. Here the water is combined with the carbon dioxide taken in through the stomata (those minute openings occurring chiefly on the under side of the leaves) to form sugars and starches. The carbon dioxide is split up and combined with water, the extra oxygen and water are given off, and the process of assimilation takes place in the presence of chlorophyll, which merely applies the energy.

As stated previously, the flow of the sap is not clearly understood, but it is known that the raw sap is conducted through the sapwood to the leaves, that it is there elaborated, and that it then passes down through the bast to the growing portions of the tree.

The part of the watery solution that is not combined passes out of the leaves in the form of a vapor, leaving the salts behind in the leaves and twigs. This process of evaporation, called transpiration, accounts for the fact that the leaves and twigs contain more mineral salts than any other part of the tree.

Consequently, when the humus, which is composed of partially decomposed leaves and twigs, is not destroyed by fire or burned up by direct exposure to the sun's rays, the fertility of the forest site remains unimpaired. In fact, the soil becomes richer year after year, because the roots are continually bringing up mineral salts from the subsoil, which are left behind in the leaves in the process of transpiration, and when the leaf fall occurs this fertility is restored to the surface soil, adding to its mineral content, as well as vastly improving the physical quality by the presence of humus. In addition, the bulk of the tree is composed of carbon dioxide and water; therefore, a very slight demand is made on the soil in growing a crop of timber. This explains why land which is far too poor to be cultivated profitably can raise a crop of timber satisfactorily. In a general way, trees only require one-fourth to one-half as much fertility as the average field crop.

In addition to the transpiration process, which results in the giving off of oxygen and water vapor, the tree breathes like any other living organism; that is, it takes in oxygen and emits carbon dioxide. This breathing of the tree goes on continuously, but is not nearly so active as the assimilative process. Consequently, much more carbon dioxide is used than is emitted and much more oxygen is given off than is consumed.

Considerable moisture is used for the building up of the plant, and large quantities of water are needed for good growth. Consequently, in regions where rainfall is scanty, trees may be present but their form will be decidedly poor.

An English investigator states that a stand of beech 150 years old will consume 400,000 gallons of water per acre per year. This seems an extremely large amount but in terms of rainfall is not excessive; in addition it must be remembered that beech is a moisture-loving species.

Tree Characteristics

Of the various characteristics, the following are the most important and will be considered in turn:

Occurrence.
Local extension.
Form.
Soil and moisture requirements.
Growth.
Tolerance.
Duration of life.
Quality of wood.
Reproduction.
Resistance.

Occurrence. Continental distribution of a species depends primarily on heat. Different species need various degrees of heat for their proper development and the carrying on of the different life processes, and there is a certain average temperature for each process in a given species.

For instance, the amount of heat required to germinate the seed of a certain species is much higher than for another, and on the ability of a plant to reproduce depends its range and natural extension.

Moisture also has an important bearing. On large continents, although heat may affect the range north and south, moisture is likely to limit tree growth east and west; the interior portions of the continent may have a rainfall that is too scanty to support tree growth.

The altitudinal range of trees is really a question of heat, since height zones due to the average temperature during the critical season can be clearly marked. The northern limit of tree growth varies from 55 degrees north latitude on the Labrador coast to 70 degrees north on the coast of Alaska, the presence of the Japan current accounting for this difference.

The timber line on high mountains grows lower as we pass from the tropics toward the pole, since the zone of the same annual average temperature descends as colder climates are approached.

In the Himalayas, the timber line is found at 14,000 feet above sea level; in the Alps at about 7500 feet; and in the Adirondacks at about 4000 feet above the sea. For the same reason, a species occurring at a given elevation in the southern Rockies will be found at lower elevations as the northern part of its range is approached.

Ecologists are at variance regarding the length of the growing season necessary for tree growth; some claim that 50° F. must be the average temperature during the four growing months; others insist that it is the temperature during the six critical weeks that count.

Concerning the southern limit for any tree, it is generally believed that excessive heat is rarely, if ever, fatal, but a northern tree transplanted to a southern climate is likely to produce infertile seed, which limits the natural extension of the species.

Also, on account of the absence of the normal resting period, continuous growth may weaken the tree so that it will succumb to some destructive agency.

To a certain degree, the continental distribution is a matter of chance, either present or past. For instance, fewer tree species are found on the European than on the North American continent, owing to the fact that following the glacial epoch trees in Europe were unable to regain the ground they had lost because they were unable to extend themselves again beyond the lofty mountain ranges running east and west.

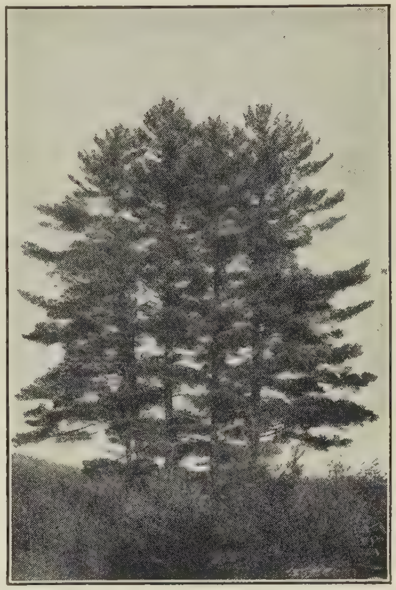


FIG. 45.—Open-grown trees are characteristically of wide, deep, dense crowns. The wood is permitted to go into the branches rather than the main stem. The reason for close spacing in planted or natural growth is to make the trees grow tall and straight and place the annual increase of wood on the main stem rather than in the side branches.

On the North American continent, the mountain ranges run north and south, and the trees, although temporarily pushed out of their ordinary habitat, did not have high mountain barriers to hold them back after the recession of the ice sheet. As a result we have over 700 tree species in America compared with 100 in Europe.

Local Extension. By local extension is meant the range of trees and character of growth exhibited within their geographical distribution.

Northern trees toward the southern part of their range are likely to be found on the northern and northeastern slopes; southern trees are likely to be found on slopes of a southerly aspect toward the northern part of their range. This point is of importance in the management of certain species, as it may be useless to attempt the natural regeneration of a tree on a given site when it is not congenial, if considered in connection with its local distribution in that region.

Form. Each species of tree has a form that is quite typical, but only a tree that has ample growing space, a pasture elm for instance, will assume this form.

When a tree is growing in the dense forest, its form will be affected by the crowding of its neighbors, and as a consequence the typical form will be altered.

Aside from the amount of growing space, the age of a tree has an important bearing on its form. Most trees attain the greater part of their height growth before there is any large diameter growth; consequently, up to the age of thirty-five to forty, the average tree is apt to be tall and slender.

Then, after the period of most rapid height growth is past, the tree begins to put on flesh, as it were, and diameter and volume growth commence to increase. So marked is this characteristic that it is possible roughly to estimate the age of a tree by the amount of taper it possesses, for if a tree carries its diameter well up into the crown it is safe to assume that it is fairly mature.

The quality of site on which the tree stands also affects its form. If the soil is thin, with little moisture, the tree is likely to be short and scrubby, while if the tree is rooted in deep, rich soil with plenty of moisture available, tall, full-boled trees are the rule. In fact, the forester often gauges the quality of his forest site by the form, and especially the height, of the trees growing on it.

Light soils produce, as a rule, long, straight boles of average diameter and medium crowns, and heavy soils commonly produce trees with heavy, round crowns and thick boles.

Soil and Moisture Requirements. Different species vary widely in the demands they make on fertility and water content of the forest soil.

In fact, one of the first things a forester should realize is that an extremely close watch must be kept on the condition of the forest soil in order to encourage the growth of the desired species.

German foresters claim that the forest soil is just what the man in charge makes it, but this remark cannot be taken too literally, since a gravelly soil with excessive drainage can never support a good thrifty stand of a moisture-loving species.

The soil should be studied in each portion of a forest so that the proper species may be encouraged on the site where it can grow thriftily and make the kind of timber that the market demands.

Hardwood species are inclined to be much more exacting than conifers, since they need about four to six times the moisture and about double the fertility that the less exacting evergreens require. Of the coniferous species, spruce requires much fresher and richer soil than pine, for example, and among the pines there are species which are less exacting than others. The red or Norway pine can grow on dry, gravelly soils where white pine would perish, and it is believed that the Scotch pine of Europe surpasses even the red pine in its drought-resisting qualities.

Such species as walnut, maple, beech, etc., need a deep, rich, moist soil for best growth, and on a site of this description they can compete so successfully with softwoods that the latter will eventually be crowded out. Such trees as poplar, gray birch, black oak, and, in the West, the pinon and juniper are decidedly less exacting in their soil and moisture requirements.

In each case there is a balance between the need for food and for sunlight. If there is plenty of food available, sunlight may be reduced to a minimum, and *vice versa,* but if a tree is found thriving under shade in a poor location it may be considered extremely tolerant.

Trees are easily satisfied in their youth and become more exacting as they grow older. In many instances, plantations started on sandy soil have thrived up to the age of forty, and then, for no especial reason, their growth rate has begun to decrease and they have fallen prey to fungus and insect attacks. This was because the site no longer sufficed and the resistance of the trees was lowered.

Growth. By growth is meant the increase of a tree in height, diameter, or volume. Of these, height growth is of first importance in the early life of a tree, since on the early height of a seedling depends its fate in the struggle for existence.

Height growth varies widely according to species, locality, and treatment. Primarily it depends on the energy of the leading shoot; the terminal bud is larger and the energy therefore is greater. Any influence which favors the formation of a hardy bud and later helps this bud to develop can be counted on to favor height growth. In many cases, reproduction will start under the shade of the older trees and for a few years appear to be thrifty. Unless the canopy is opened, the seedlings will lose their thrifty appearance, the foliage will change to a pale, yellowish green, and the buds, instead of being large and vigorous, will become small and weak. When this happens, light must be given immediately or the reproduction will die.

Of all the factors influencing height growth, light perhaps is of paramount importance since it is absolutely necessary for the assimilation of plant food. Direct light is not absolutely necessary at first, and by some it is believed to retard height growth, for the lengthening of the shoot takes place in the night or in the early morning hours. The energy of the sun's rays, supplied either by direct or diffused light, must be available, else growth of any kind will cease.

Heat also is indispensable for growth. Below 0° C. growth practically ceases, although certain species of Arctic plants grow through the snow. Above 40° to 50° C. growth also stops on account of excessive heat. The optimum temperature is considered to be from 20° to 30° C., depending on the individual habits of the species.

Water is absolutely essential for life and growth, since cell division is dependent on the presence of water within the cells; in fact 95% of the growing tissue of a plant is water. Vigorous height growth is an index of sufficient water as well as plant food in the soil, and lack of moisture nearly always causes scrubby growth.

Aside from the effect of the site on the height growth of a given tree, the species itself is extremely important. Of all the trees found in the United States, the exotic eucalyptus is capable of attaining the greatest height; but of the native species the sequoia has that distinction, reaching a maximum height of from 320 to 350 feet.

A tree increases in height most rapidly during the early part of its life, and, after the bulk of the height growth has been attained, the diameter and volume growth tend to increase. Intolerant trees are generally the fastest growing; sprouts also grow faster than seedlings of the same species, owing to the large root system already formed, but the growth of sprouts soon culminates.

Extreme density is apt to decrease height growth, owing to the reduction of light and excessive competition between the roots; but reasonable crowding is beneficial, since with unlimited growing space the bulk of the growing energy of the tree is dissipated in branch production rather than in producing a large, straight, cylindrical bole.

A tree increases in diameter by laying on a ring of wood each year deposited by the cambium layer, and the increase in volume depends on height and diameter growth together. On the whole it might be said that they are subject to the same laws as height growth, but species is relatively of more importance. The increase in volume is likely to begin earlier with intolerant trees since the struggle for existence is terminated earlier with light-demanding individuals, leaving fewer trees standing on the site to utilize the solar energy and plant food. Trees having the same height may differ in diameter as 1 : 4, depending on the closeness of the stand.

Since between 50 to 60% of green wood is water, it is found that the dry weight of wood produced by trees of different species is much closer than the volume produced per unit of area in the same time. Consequently trees of light specific gravity are the best volume producers and, since tolerant trees can stand

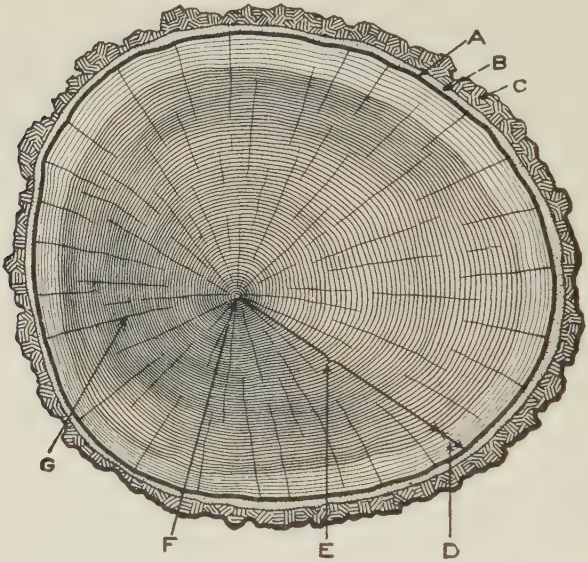


FIG. 46. Cross-section of tree trunk illustrating how a tree grows. *A* is the cambium where all growth takes place between the inner bark and sapwood. *B* is the inner bark, soft and moist, which carries food prepared in the leaves to all growing parts of the tree. *C* is the outer bark which serves to protect the tree against evaporation of moisture in the inner bark and from mechanical injury. The woody growth during one season is called an annual ring. This section shows many annual rings. During the spring the newly formed cells are thin-walled and spongy and form the springwood and in the summer the cells become thicker and denser and form the summerwood. The springwood is generally light and summerwood, darker colored. *D* is light colored sapwood between the bark and the heartwood and is often from ½ to 2″ thick, or more. It carries sap from the roots to the leaves. *E* is the heartwood formed by a gradual change in the springwood, whereby it becomes darker, heavier, and more durable. Heartwood is not living and serves only the function of support. *F* is the pith or soft tissue about which the first woody growth takes place. *G* shows a pith ray, which is a flat vertical band of tissue connecting the pith with the various layers of wood and the inner bark. The pith ray transfers and stores up food.

closer together and can assimilate food from the air and soil equally well, it follows that the largest volume per acre is produced by tolerant trees of light specific gravity.

The size of the crown as a rule is ordinarily a good index of the amount of volume growth, for a tree with a large crown can elaborate more food to be distributed about the trunk. One theory concerning the distribution of growth is that woody material is laid on in the greatest amounts where it is needed most; that stress in the tree acts as an irritant, as it were, and that extra amounts of wood are laid on where the strain and irritation is the greatest. Trees that are standing in the open have thick trunks at the base where the strain is the greatest and trees leaning downhill have the widest rings on the downhill side.

After Pinchot, trees may be classified according to their size as follows:

Up to 3′ in height —	Seedlings (provided they are of seedling origin).
3 to 10′ in height	Small saplings.
10′ in height, 4″ in diameter	Large saplings.
4 to 8″ in diameter	Small poles.
8 to 12″ in diameter	Large poles.
1 to 2′ in diameter	Standards.
Over 2′ in diameter	Veterans.

Tolerance. The ability of a tree to endure shade is called tolerance. The amount of shade that different trees can bear varies widely according to the species.

Of all the factors that influence tolerance, the amount of food and moisture available is the most important, for if a plant has enough food and just enough light to assimilate it, the tree can thrive; but if the amount of food in the soil is barely sufficient the tree needs plenty of solar energy to elaborate the amount of food required.

In this connection, the length of the growing season is of great importance, because a long season permits the tree to lay up a large amount of food in the parenchyma on the days that diffused light is available; therefore we often find that trees in the southern part of their range are much more tolerant than they are in the northern part. The red cedar, commonly regarded as an intolerant tree in the North, grows quite frequently in the South under the shade of the yellow pine.

Trees possess inherent characteristics concerning the amount of shade they can bear. Species like the pitch pine, aspen, and western yellow pine, are ranked as intolerants and require full sunlight for their development. Trees like white pine, yellow birch, and chestnut are in the middle of the scale; while beech, hemlock, hard maple, western red cedar, etc., are markedly tolerant and can grow in quite heavy shade. Some of the important trees might be classified regarding tolerance as follows:

HARDWOODS

Tolerant	Intolerant	Intermediate
Hard maple	Chestnut	Black locust
Beech	Red oak	Tulip poplar
Red maple	Butternut	Gray birch
Black gum	Ash	Black cherry
White elm	Black walnut	Hickory

CONIFERS

Tolerant	Intermediate	Intolerant
Balsam fir	Loblolly pine	Larches
Hemlock, eastern and western	White pine	Lodgepole pine
Spruces, eastern and western	Scrub pine	Ponderosa pine
	Red fir	Eastern red cedar
	Douglas fir	Pitch pine
White fir	Western white pine	Norway pine

Intolerance is a characteristic which tends to increase with age. White pine seedlings can grow and thrive for a few years in the shade of older trees. However, the increasing need of light soon becomes apparent. Their leaves become pale yellow instead of a deep, lustrous green, and their buds become smaller and less vigorous in appearance.

Shade-bearing species usually have the following characteristics:

The forest has a dense canopy, the trees have thin leaves, thin bark, thick sapwood; branches are persistent, and on the ground a thick layer of humus is usually found, owing to the density of the canopy which shades the soil and retards normal disintegration of humus by largely excluding the sun's rays.

Tolerant trees, as well as those having a low requirement for plant food and moisture, have a great advantage in seizing and holding forest sites. Owing to their ability to stand shade, they will ultimately crowd out more intolerant species and occupy large areas, provided a proper dissemination of seed is possible. Light-seeded trees, like the aspen and gray birch of the Northeast, often seed in over-large areas after a forest fire, but they merely constitute the " nurse crop " and are generally crowded out by the slower growing but more tolerant individuals like the white pine and spruce.

Duration of Life. The length of time which a tree lives depends largely on a combination of internal and external conditions. Some scientists claim that a tree never dies of old age, but that its death is always due to external factors. However interesting that statement may sound, it is true that there are certain definite ages which given species do not seem to exceed, and ordinarily there is a certain average age which may be put down for each species.

Some species are remarkably long-lived. The sequoia, attaining an age of 3500–5000 years, is the longest-lived American tree. Short-lived species are also noticeable in the way they tend to disintegrate at certain ages. For instance, a stand of aspen generally breaks up at about ninety years of age; in fact, the best yields are obtained when the stand is cut at about twenty-five years of age, as the growth rate falls off early.

The bulk of a tree lasts but a few years and then becomes inert; the sapwood, which is alive, gradually turns into heartwood, which serves chiefly to stiffen the trunk of the tree. The growing points of a tree, however, are alive and continually expanding.

To attain the maximum age, which is normal for a given species, conditions must be favorable. There should be sufficient room for proper crown development and there also should be sufficient space for the roots to develop without excessive competition. If the site is sufficiently good and if there is enough light, the life of a tree will be greatly prolonged. In fact, trees growing in the open are considerably longer-lived than those of the same species grown in forests.

Of short-lived trees, poplar, balsam fir, and gray birch are the best examples of the eastern species which reach their climax between 60 and 80 years. Lodgepole pine for the Rocky Mountain species is considered short-lived, maturing at 120 to 200 years. Beech and maple may be considered mature at an age ranging from 300 to 400 years, and white oak, Douglas fir, sugar pine, and western larch average about 500 years. The sequoias, as before mentioned, are examples of long-lived trees, as the big tree reaches an age estimated from 3500 to 5000 years and the redwood may live from 1000 to 1500 years.

Quality of Wood. The quality of wood laid on by any species is very largely a matter of the individual. For instance, spruce wood is composed of long fibers which make a light, elastic wood, extremely valuable both for wood pulp and musical instruments. Oak produces a dense, heavy wood which can withstand considerable crushing force, and consequently the two are used for entirely different purposes, the difference in structure affecting the use.

Within the same genus there is considerable difference in the quality of wood produced by the different species. Longleaf pine, for instance, is dense and hard and resists longitudinal pressure almost as well as white oak. Loblolly pine, on the other hand, is quite brittle and is of little use where great strength is required.

Rapidity of growth also influences the strength and quality of wood. As a rule, it may be said that in ring-porous woods, like chestnut and oak, the more rapid the growth the stronger is the wood produced, because after springwood has been formed, the dense layer of summerwood is added to the growth ring. This latter part is really the supporting portion of the ring, and the faster the growth the larger is the proportion of the summerwood. Consequently, chestnut sprouts are considered stronger than the more slowly growing seedlings and are in greater demand for piles and poles.

The influence of the quality of the soil on tree growth also is quite remarkable. Light, sandy soil tends to produce a fine-grained wood which is usually less tough and of less fuel value and durability than specimens grown on heavy soil. On clay soils the growth is apt to be slow in youth, and the stands mature later in such situations. The wood is exactly the reverse of that grown upon sandy soil, being heavy, durable, tough, and of good fuel value.

Reproduction. This characteristic of a tree is of extreme importance to a forester, as on the successful starting of new growth depends the future forest crop.

There are three methods of natural regeneration:

1. By seed.
2. By sprouts.
3. By suckers.

1. *Reproduction by Seed.* Seed production depends physiologically on the ability of a plant to elaborate more food than it needs for growth, and, after accumulating surplus food in the parenchymatous tissues for several years, to dispose of the extra energy by bearing an unusual quantity of seed. Some seed is produced every year as a rule, but these years of large seed production, called " seed years," vary with different species as far as frequency is concerned and indeed within the species, depending on climatic conditions, site, etc.

Some species are noted for the frequency of their seed years and the total amount of seed produced. Others may produce a very small amount or an average amount with low fertility percentage. Light-seeded, intolerant trees are more likely to produce a great deal of seed, and such trees as birch and aspen are likely to seize upon any piece of land whose surface meets their requirements for a germinating bed. If a species makes but slight demands on the soil during the early part of its life, the chances are so much the better that a permanent stand will be established.

Light, next to food, of course, is the most important consideration in seed manufacture. Consequently, open-grown trees produce a larger amount of seed than those grown in close stand and can produce seed at a much earlier age. Twenty-five years is the average age at which open-grown trees begin to bear seed, but those in close stands will begin to bear at forty years as a rule. Forest-grown trees bear their seed chiefly at the top; those submerged beneath the canopy of the forest rarely bear any seed at all. A tree growing in the open, with plenty of light available, will bear seed at the ends of practically all the branches.

Heat is also of importance in seed production, as a tree growing in its optimum range or toward the southern part of its range is likely to bear more and better seed than a tree of the same species much farther north, owing to more favorable growing conditions. Seed years are due to the favorable temperature and moisture conditions of the previous season or seasons, and therefore are likely to become more frequent with good climatic conditions and freedom from any disturbance, such as defoliation, drought, etc. They do not occur in the same year throughout the range of the species, but the interval may be about the same. For instance, the white pines in Maine may have a splendid crop of cones, and those in the Adirondacks may be bare of cones the same year.

Some species bear seed at a very early age, but, as a rule, the seed produced is likely to be of low fertility. Lodgepole pine has been known to produce seed as early as six to eight years, jack and scrub pine at about the same age, and pitch pine at about ten years of age.

Seed production, however, is at its best in the economy of the tree after the period of most rapid height growth is past. At this time the crown commences to develop, and the food supply begins to catch up with the demand. When silvicultural maturity approaches, that is, when the stand begins to open up and reproduction starts naturally, seed production is likely to be at its best.

Seed is produced by trees until they are very old, and it is not uncommon to find a tree producing a heavy crop of seed a year or two before it dies.

There is a wide difference of opinion about the quality of seed produced by these old trees and the quality of reproduction that will result if they are left as seed trees. Some believe that the seedlings will be weak, while others state that while the fertility may be low, the seeds that are fertile will produce good stock, as the individual seed bears the imprint of ten thousand ancestors and is not affected by the condition of the immediate parent.

2. *Reproduction by Sprouts.* Starting a forest by means of sprouts is known as coppicing and is a very desirable means of regeneration with certain species, as maple, chestnut, and catalpa. It should not be continued too long, as it is likely to exhaust any but the richest and heaviest soils, on account of the frequent exposure of the earth to sun and wind.

Practically all hardwoods sprout during youth, but some retain their sprouting capacity longer than others. Seedling chestnut will sprout up to 120 years of age, but sprout chestnut has difficulty in coppicing after 60 years. Under ordinary circumstances the coppice method should be used only on short rotations, as the sprouting capacity is likely to be uncertain after 40 years.

Repeated coppicing tends to lower the vitality of the parent stump, and consequently many blank spots are found in a forest that has been repeatedly coppiced.

A few of the conifers sprout, but the sequoias are about the only species of conifers that produce sprouts of economic importance. Shortleaf and pitch pine are quite frequent sprouters under certain circumstances, but the sprouts produced are short-lived and of little importance.

3. *Reproduction by Suckers.* By suckering is meant the sending up of shoots from underground roots. This method of

reproduction is not of economic importance, as a rule, because the suckers of most species are extremely likely to die. In certain species, however, such as beech and poplar, growth from suckers is often responsible for the extension and maintenance of the stand. Black locust also reproduces in this way, and when it is once established in a field, the more the mature trees are cut out, the denser will be the thicket of suckers sent up from the roots.

Resistance. Trees, like people, are damaged by various agencies, and different species are able to resist these agencies in varying degrees.

Among the enemies to the forest, wind, snow, insects, fungi, and fire may be mentioned, and each will be considered in detail in the chapter on forest protection.

The individual resistance of a given species is of extreme importance in forest management, and the desirability of a tree depends on its vitality and ability to throw off the attacks of various enemies. Trees like white oak, which is particularly favorable to the spread of the gypsy moth, and the white pine, which is badly attacked by the pine weevil and blister rust, are discriminated against in regions where such pests prevail.

An intimate knowledge of the relative resistance of the different species is part of the forester's stock in trade, as on such knowledge is based the decision concerning mixtures to be used in planting or species to be favored or discriminated against in a thinning or reproduction cutting.

The Tree as a Unit

The tree, to the forester, is the fundamental unit which in large numbers forms the community, the forest, in which he is chiefly interested. It is upon the forest, its relations and reactions that the forester bends his energies. The characteristics of a tree, its soil requirements, its reactions to light, its height, growth, etc., are only interesting and important in so far as they affect the selection of site, the density of the stand, the outcome of the struggle for existence. In other words, forestry is a science in so far as it is based upon the close and intimate knowledge of the single tree as a unit; it is also an art because it applies this scientific knowledge of the needs and habits of the individual, in producing timber from trees grown in groups or communities.

CHAPTER V

SILVICS — RELATION TO ENVIRONMENT

The Forest as a Community

A forest is a community of individuals which has a life of its own. It is more than a mere group of trees, since it includes not only the tree but the soil, the undergrowth, and reproduction. The German foresters have for a long time included the game and stock within the realm of the forester's activity. On many of the National Forests in the West a large part of the Forest Supervisors' time is given to these problems.

The component parts of a forest bear the same relation to each other as do the individuals in a town or village. The trees are mutually dependent and at the same time competitive. They protect each other against windthrow and snowbreak, and the close canopy allows the formation of humus; yet they compete for food, moisture, and light. So sharp is this competition that a stand of 100 trees per acre at 200 years may be the final survivors of 10,000 seedlings which started on that acre, the balance having perished in the struggle for existence.

The duty of the forester is to learn the habits of the trees which make up this community so that congenial species may be encouraged and the maximum growth of the forest as a whole be secured.

Characteristics of a Forest

The knowledge of the life, development, and need of the various trees constitutes the science of silvics, while silviculture, based upon this knowledge, is the art of tending the forest community to produce the maximum amount of timber in the shortest time.

A forest must possess the following characteristics:

First. The crowns *must meet* so as to produce a certain amount of shade.

Second. Natural pruning must have commenced, so that there is some clear space on the forest floor, *i.e.,* the canopy must not begin immediately above the ground.

Third. There must be an accumulation of humus on top of the mineral soil.

Fourth. The form of the individual must be typical of the forest, rather than of open-grown trees.

A young plantation will not meet the above requirements and thus cannot be considered a forest until the crowns meet and some natural pruning takes place. The above conditions cannot be fully met in such situations as the arid Southwest, where an open stand is unavoidable, owing to limited moisture.

Division of a Forest. For the purposes of description and management, a forest is often divided into various parts. The terms used to characterize these portions will be briefly defined.

Stand. A generic term referring to a specific part or the whole forest. It usually needs further qualification, as " even-aged stand," " *dense* stand," etc.

Type. A part of the forest having a distinct individuality that requires separate treatment. It is the ultimate unit in description and intensive management. Types may be based on site quality, composition, age, etc.

Influence of Forest on Locality

Aside from the importance of forests in producing timber, they exert certain influences which make them practically indispensable. In certain regions these indirect influences may be paramount to timber production, as in the mountainous regions of France, and in fact in parts of the United States where water is at a premium. In the former country, steep slopes are being sodded and planted on a large scale primarily to assist in controlling the mountain torrents rendered unmanageable by over-cutting subsequent to the French Revolution.

New government conservation agencies have recently recognized the important influence of the forest on the social and economic welfare of farm and forest lands — especially the Soil Conservation Service and the Tennessee Valley Authority.

The indirect influences which forests exert are felt in three ways; *viz.* effect of forests on

1. Climate.
2. Precipitation and runoff.
3. Soil.

Climate. Whatever influence forests have on climate is somewhat localized. It is well known that the climate of a wooded area is more equable than that of an open country, since the ground is less exposed to insolation, the radiation of heat is checked, and the currents are retarded. This action of the forest is of great value in hot countries, and advantage is often taken of it in rendering windswept areas more habitable by planting windbreaks. Forests exert the greatest change in the climate during summer, with spring following, next autumn; and the least influence of the forest on climate is felt in winter. Humidity is increased by the presence of large bodies of forest cover, since the relative humidity of forest air may be as much as 10% higher than the humidity in the open spaces near by.

Precipitation and Runoff. It is very doubtful if the presence of forests has any marked effect on the amount of rainfall. However, experiments carried on by French and Swiss foresters indicate that under certain circumstances large masses of forest cover at high elevation may tend to increase the annual amount of precipitation by chilling the moisture-laden atmosphere.

For the most part, however, this effect of forests is not conclusively proved, and the forests are chiefly considered as retarding the runoff of the water precipitated.

Runoff and Erosion. Following a rainstorm, the speed with which water reaches the rivers depends very largely on the condition of the surface of the soil and its porosity, as well as on the slope. As far as heavy spring showers are concerned, it is estimated that fully 25% of the rainfall is caught by the trunks, branches, and leaves, causing this portion of the total precipitation to reach the soil after the bulk of the rain has been soaked up by the humus and litter. Some part of the precipitation is evaporated from the trunk and branches directly into the air, and never reaches the soil at all.

Tree roots also have their part in retarding the runoff, for wherever they enter the soil, basins are formed in which small pools of water collect. These act as miniature storage reservoirs, running off to the next basin farther down the hill when the upper one becomes full.

The humus, of course, is one of the most important parts of the forest in affecting runoff, owing to its composition and structure. It is extremely hygroscopic and can hold many times its own weight of water; and the relative water-holding power of a watershed covered with dense forest is much superior to that displayed by a steep slope denuded by fire. On the whole, the forest, from canopy to humus and roots, acts as a great sponge which must be filled before the excess water will run off in the streams and rivers. Snow lies longer in the spring beneath the forest cover and when it melts is largely absorbed by the porous forest soil. Springs are much more common in forested land than in the open, and brooks and streams are more likely to have continuous flow if the watershed is forest-covered than if it is denuded.

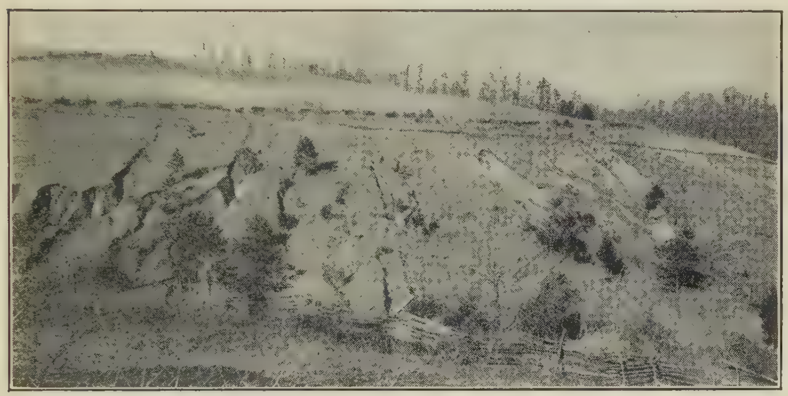


FIG. 47.—Typical example of improper land use in the Tennessee Valley, where slopes too steep for agriculture are seriously eroded after the forest cover has been removed. The silting soils often ruin crops in the valleys and much valuable agricultural land is destroyed. There are many thousands of acres exhibiting similar conditions in eastern Tennessee. (Photograph by Tennessee Valley Authority.)

The effect of forest cover is most noticeable in mountainous countries having steep slopes, deep alluvial soil, and heavy rainfall. Such regions are likely to suffer badly from erosion after the forests are removed. In extreme cases the damage is not confined solely to cutting away fields on the upper slopes; during floods the bottom lands may be covered with sand and gravel, rendering fertile land unsuitable for agriculture. It is estimated that upward of 200 square miles in the United States are annually laid waste by erosion, while the alluvial soil deposited at the delta of the Mississippi represents the fertility of thousands of acres. Steep slopes subject to erosion should not be clear cut; or, if some clearing is necessary for agriculture, strips of forest land following the contours should alternate with the cleared areas to check the force of the runoff.

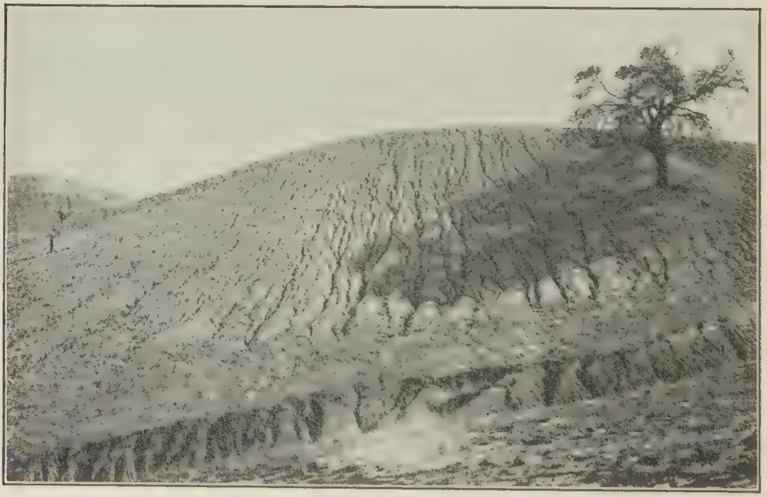


FIG. 48.—Heavy gullying on bare ground in comparison with no gullies under the protection of an oak tree. The roots of this tree, some of which have been uncovered and can be observed, extend 120′ out from the tree to the figures at left. California.

Soil. While trees undoubtedly withdraw fertility from the soil, their general effect is to enrich rather than to exhaust, the reason being that the roots of the trees draw large quantities of soluble salts from the lower strata of the subsoil and deposit

TRANSPIRATION = leaves giving [illegible] vapor [illegible]

these salts in the leaves and twigs during the process of transpiration. When the leaves fall these salts are deposited on top of the surface soil and gradually decompose under the action of bacteria, fungi, etc., thereby adding to the richness of the surface soil.

The physical condition of the soil is also improved by the forest. The presence of roots, either actively growing or decaying, adds to the porosity of the soil, and the effect of humus in correcting the binding quality of clay and improving the cohesiveness of sandy soils is well known.

Nowhere is the influence of forests on soil more marked than in the pine barrens of the South. Numerous cases can be cited where fields were covered by " old-field pine " (*Pinus taeda*) after the Civil War and a splendid crop of timber was grown. On clearing the land, splendid crops can be raised for the first three or four years, drawing upon the richness which had been deposited by the forest. At the end of that time the accumulation of humus and organic matter has been exhausted, crops commence to decrease in value, and within a few years the land is abandoned and the cycle starts again.

Influence of Locality on Forests

(*Factors of Location*)

A tree, or a forest composed of trees, is largely affected by environment; consequently ecology, the science dealing with the dependence and adaptation of plants to their environment, is extremely important in the proper handling of forests. Different species react differently to the various factors, and as a result different kinds of tree communities are produced.

The most important ecological factors are: air, light, heat, moisture, soil, and exposure.

Air. Air is composed chiefly of nitrogen and oxygen, with a limited amount of carbon dioxide, all of which are necessary to plant life. The relative proportion of the component parts varies but slightly at different locations and elevations. However, in some regions, the atmosphere may contain certain gases or constituent parts which may have injurious effects on plant life. Sulphur dioxide, for instance, may be found in perceptible quantities in the air near smelting or pulp plants and may kill plant life within a radius of several miles; and salt winds from the ocean are found to be injurious to certain kinds of trees.

All plants take carbon dioxide from the air and in the presence of light and chlorophyll build up the carbohydrates with the addition of the water taken in by the roots. Some of the legumes have the additional power of absorbing the nitrogen from the air and fixing it in the soil through the medium of nodules of bacteria attached to the roots.

Light. Light is the source of all energy and has been discussed in its bearing upon growth. The effect of light depends largely upon the season, as its intensity decreases with the obliquity of the rays of the sun. Latitude and altitude also affect light, the intensity decreasing toward the north but increasing with altitude.

The duration of light is as important as its intensity, since a definite amount of energy and plant food is required by each species. Trees having more sensitive chlorophyll or having leaves with better arrangement have an advantage, for with the same amount of light they can exceed their rivals in vitality. Shade bearers, for instance, can produce vigorous buds with only diffused light, and certain of the tolerant trees, like spruce and beech, can thrive with little direct sunlight. Very little light is required in extreme youth, as the seed can germinate in shade and grow for a short time on the food stored in the cotyledons, but growth cannot be kept up for any length of time without the energy which light affords. During advanced age also the tree needs but little light, the greatest demand for light being made during the period of most rapid growth when large amounts of energy are required.

Heat. For each plant there is a certain optimum, maximum, and minimum temperature. Cell division, transpiration, and assimilation all require a certain amount of heat. Heat is influenced by the following factors:

First. Elevation above the sea level. It is claimed that, in the Alps, an increase of 300 to 400 feet in elevation results in lowering the average annual temperature one degree.

Second. The presence of large bodies of water. Large lakes or bays store up heat during the summer and release it slowly in the fall and winter. On the whole their tendency is to retard the seasons and to prevent rapid fluctuations in temperature.

Third. Aspect and gradient. Sites facing southwest to southeast have a higher annual temperature than those facing northwest and northeast, and the angle at which the sun's rays strike the ground also affects the amount of heat available.

Fourth. Presence or absence of forest cover. Open countries without lakes and forests are subject to much more rapid change of temperature than the forest regions which are well watered. The forest protects the soil from insolation, increases the relative humidity of the air, retards drying winds, and in general renders the climate more equable.

Moisture. As has been stated in the preceding chapter, moisture is of extreme importance for plant life and growth. There are two kinds of moisture, soil and atmospheric. Some species, like hemlock, prefer locations where there is plenty of both; others, like the eastern larch, seem to require plenty of soil moisture alone. Atmospheric moisture, however, is of great importance, since it is not only the original source of the precipitation, but also controls the rate of transpiration which, in turn, has its effect upon the intake of nutrient solutions.

The importance of *soil moisture* in plant economy is more apparent, having the following functions:

First. It regulates the temperature of the soil by evaporation.

Second. It is the solvent for salts which are absorbed by the root hairs.

Third. With carbon dioxide absorbed by the leaves, it is worked up into starches and sugars in the presence of chlorophyll.

Moisture in the plant has the following functions: it increases the toughness of the wood, it makes the salts within the cell soluble, and it permits the plant to accommodate itself to changes in temperature by increasing or decreasing the amount of water evaporated. In locations where the temperature is the same, the amount of moisture available controls, to a large degree, the local distribution of given species.

Plenty of moisture in the soil, however, does not necessarily mean adequate moisture for growth, since certain factors influence imbibation. Salt in the soil, for instance, has a drying influence on the roots, owing to disturbance of osmotic pressure. Humus acids prevent the taking in of water, and frozen soil makes it impossible for the water to pass through the cell wall. Consequently, a tree growing at high elevations in a rare atmosphere, where transpiration is intense, is apt to suffer from limited water supply in spite of heavy precipitation.

Trees requiring moisture:	Trees enduring drought:
Cottonwood	Norway pine
Tulip tree	Jack pine
Black ash	Pitch pine
Red maple	Eastern red cedar
Cypress	Black oak
Black spruce	Chestnut oak
Eastern hemlock	Black locust
Eastern larch	Longleaf pine
Western red cedar	Ponderosa pine

The coniferous trees generally require less moisture than broadleaf species, and in some respects might be classed with those intermediate as to soil moisture, like chestnut, red and white oak, etc.

Soil. The character of tree growth in any region is governed largely by soil. The forester considers soil to comprise not only the mineral portion resulting from weathering of rock, but also the organic material which has been added through the decay of vegetable growth on top of the mineral portion, because on the effect of both together depends the reaction of the tree to the site.

The component parts of forest soil may be described as follows:

The uppermost layer of the " forest floor " consists of the recently fallen leaves, which have undergone little or no change in structure; the middle layer consists of leaves which have commenced to decay but still show traces of their original structure. The " humus," a black, crumbly layer lying directly above the mineral soil, is the result of the further decay of the leaf litter, but shows no trace of its former structure. It is this portion of the forest floor which supplies the richness for tree growth, and the rapidity of the forest growth depends largely on the proper decomposition of this layer.

The " mineral soil " is that part which has been formed by the disintegration of rocks and rock materials.

The requirements for normal decomposition of humus are bacteria or fungi, sufficient heat and moisture, and proper amount of air. Long winters with resulting short growing seasons ordinarily mean deep layers of humus, and in the north woods it is not uncommon to find the duff or litter anywhere from 1 to 3 feet in depth. Compact soils ordinarily have a deep layer of litter, while porous soils are apt to be extremely hungry and rapidly consume the humus. It takes two to three years for hardwood leaves to disintegrate to humus while coniferous needles take longer, four to five years on the average, and even up to eight years. The extra durability of the needles is due to the presence of resin.

The physical properties of the soil are perhaps of greater importance to the forester than the chemical, because on account of the low fertility required by forest growth practically any soil is able to support tree growth, provided sufficient moisture is available. The chief physical properties of the soil may be enumerated as:

1*st.* Consistency.
2*d.* Water-retaining capacity.
3*rd.* Permeability.
4*th.* Capacity to become heated.

Of these, consistency and, incidentally, permeability are perhaps the most important. Unless the soil structures are sufficiently permeable, the water will not sink into the soil and, consequently, will not be available when needed. Exclusion of air from the soil will result in the killing of the roots, since the roots require air as much as the leaves do. This may be proved by noting the frequency with which trees die when their roots are covered with additional earth following grading operations. This has led to the hypothesis that the knees of the cypress have been developed as a breathing organ to supply air to the roots during the gradual lowering of the southern coastal plain.

The ordinary texture and permeability of the soil is wonderfully improved by the addition of humus. It tends to loosen binding soils, makes them more permeable to air and water, and also adds to the hygroscopicity and water-holding capacity of sandy soils. Humus tends to correct the faults of all soils that are due to physical structure, and at the same time adds greatly to their fertility.

The soil itself contains life, as it shows changes in form and composition from time to time. Darwin, as a result of his investigations, has shown the extremely important role played by worms in changing the chemical composition and physical structure of soil, proving that they neutralize acid, assist in working the soil and mold together, and increase porosity.

In addition to animal life in the soil, the bacterial action is extremely important. Investigators claim that one pound of humus contains anywhere from ninety to two hundred and fifty millions of bacteria, and their presence may determine the success of tree growth as well as that of agricultural crops. Spruce, for instance, can grow on poor sandy soil, provided Scotch pine is mixed with it, since the additional nitrogen added to the soil by the mycorrhizae of the Scotch pine roots, makes the growth of spruce possible. Animal life is found to be most numerous in the upper two feet of forest soil; below six feet it practically ceases to exist.

Exposure. The direction in which a slope faces often has an important bearing on the kind and quality of tree growth found upon it.

A northern slope gets no full sunlight and the rays fall obliquely. Winds are cool but not drying. Snow melts slowly in the spring, hence the ground is more moist. All points are in favor of easy germination of seed, hence natural regeneration is easy. It is a most desirable aspect.

The east slope is cool and moist; fairly late in spring, vegetation is late in starting; consequently, there is little damage from late frosts. On the whole it ranks next to a north slope.

The south and west slopes are ordinarily the least desirable. The ground is parched by the sun and wind; seeds are apt to dry out, making natural regeneration difficult, and sunscald is quite common in thin-barked trees.

All these conditions may vary in different parts of the country, depending on local factors. In the Puget Sound country, for instance, the west slopes receive the heaviest rainfall and support the densest growth.

Formation of Forest Types

By forest type is meant the ultimate subdivision of a forest into groups sufficiently distinct to affect its management. Forest types in nature are formed in many ways.

The average forest, if left absolutely undisturbed by natural agencies, including fire, insects, and wind, and if secure from lumbering operations, would, in the course of a century or more, develop into what is called a climax or ultimate type of forest which is suited to the particular region in which it grows. In this forest would be found trees of many ages, and many different species, and, for the most part, reproduction would be started beneath holes in the canopy made by the death of veterans. In short, in the virgin forest, growth is generally balanced by decay.

Aside from species and composition, types may be separated on the basis of topographic situation, as cove, valley, or ridge type.

Age and quality of site are sometimes used as qualifying factors, aside from composition, and may separate portions of the forest containing the same species. Examples of these types would be Northern Hardwoods, Quality II, or White Pine, 21 to 40 years.

Pure versus Mixed Forests. The controversy over the advantage of growing forests composed of one species alone or several species mixed together has been long drawn out among European foresters. Among American foresters also there has been a wide difference of opinion.

With intolerant species, like western or southern yellow pine, whose natural tendency is to grow alone, there can be little choice unless underplanting is resorted to later, to protect the soil and thereby improve the growth rate. Tolerant species growing at first in a mixed forest may ultimately become pure by crowding out the competing species.

Other species, however, like white pine or spruce, may be grown either pure or mixed with certain advantages attached to either method.

Pure forests are easy to start artificially or naturally during a good seed year. Since the silvical characteristics of at least 80% of the trees is the same, a pure forest is easy to tend. At maturity the marketing is comparatively easy, since there is a large quantity of one kind of lumber to be sold. However, pure forests, composed of 80% or more of the same species, are subject to excessive damage from insects or fungi and in case of shallow-rooted species may suffer severely from windthrow.

Mixed forests, on the other hand, are not troubled so severely with insects or fungi as there is not such a large number of the required host. Windfirm species protect those with shallow roots and there is less competition, owing to the different heights and the varying root habits of the different species. Owing to the dense canopy the soil is kept in splendid condition, natural pruning is more rapid, and larger yields are the rule.

However, great skill is needed to bring a mixed forest to maturity. There are many different requirements for light, soil, and moisture, and sometimes the tree desired may be crowded out by some faster-growing species of low commercial value, which was merely inserted as a filler.

One of the most serious drawbacks to mixed forests is the difficulty experienced in marketing small quantities of several different species. While there is no serious drawback in Europe, where timber markets are fairly stable, it may for the present prove a disadvantage in the United States. The general tendency in American forests at the present time is to use simple mixtures, preferably in groups, suiting each species to the proper soil.

Life History of a Forest

Various points covering the development of a seedling have already been given in this and previous chapters. The development of the forest, as a whole, will now be considered.

The simplest condition would be to trace the development of a plantation:

At first the trees stand far apart, each having sufficient room, and all crowns reach the ground. At the end of eight to ten years in a 6 by 6 spacing, the lower parts of the crowns have developed to such an extent that some of the branches interlace; some twigs die out from too much shade, and natural pruning commences. At this point the life of the forest begins.

The form of the individual tree now changes, the canopy rises above the ground owing to continued natural pruning, leaves accumulate on the soil, the forest floor commences to form, and the characteristics of a forest tree become more apparent.

From this time on the struggle for existence is most keen. Tree classes soon form, and those possessing the most vigor soon commence to surpass and suppress their less vigorous neighbors.

At the end of, say, forty years, the various tree classes are well defined. They may be described as follows:

(5)

1. Dominant trees; those overtopping all others.
2. Co-dominant; thrifty trees slightly below class 1, but still receiving light on the sides of the crown.
3. Intermediate; trees rapidly falling behind and now receiving light only on the top of their crowns.
4. Suppressed; individuals hopelessly submerged beneath the canopy.
5. Dead; those trees which have already succumbed in the struggle for existence.

From middle age to maturity the struggle is not so keen as during the period of most rapid growth; but individuals drop out from time to time, so that at ninety to one hundred years only a fraction of the original number remain.

As maturity approaches and each surviving tree has appropriated all the growing space it needs, a still further diminution in numbers is noticed. The canopy opens up, seedlings appear on the ground beneath, and silvicultural maturity, the time when the forest naturally reproduces itself, is at hand. From this time on the veterans will gradually die and their places will be taken by seedlings growing up from beneath until gradually the ultimate or climax forest for that region and site will cover the ground.

Forest Description

In order to cover all points needed to determine the silvicultural treatment of a forest, all factors of site and every point regarding the condition of the forest which would affect its growth, development, or needs must be taken into consideration. To that end the forester makes an exhaustive study of a piece of woodland prior to commencing operations and the following points are covered in the description:

General Description of Forest

First. Location and Area. It is always wise to bound a forest and locate the different portions, even though the region be entirely familiar. Accurate measurement of boundaries and estimate of area are essential where lumber is valuable.

Second. Physiographic Feature. Under this heading we include the topographic formation, underlying rock, the soil with regard to general character distribution, and its influence on forest types.

Third. The Forest Proper. Under this we are concerned with the general composition and origin of the forest, whether, for example, hardwood or coniferous, whether of sprout or of seedling origin.

Under the forest types we consider in detail the following:

(*a*) The proportion of the forest area in each type.
(*b*) The relation between type and site.
(*c*) The species present and the various percentages.
(*d*) The density, age, and distribution of forest types.
(*e*) The size of the trees, height, and diameter.
(*f*) The condition of the forest floor, including humus, litter, and ground cover.
(*g*) Character of reproduction.

Fourth. Condition of the forest by individual types. Under this heading is covered:

(*a*) The silvicultural needs of each type.
(*b*) The damage caused by fire, windthrow, insects, and fungi.
(*c*) Possibilities of lumbering.
(*d*) Merchantable condition of the forest.

These topics when properly treated will give a clear and comprehensive idea of the forest conditions that will enable proper recommendations to be given for its management. While some of the points may seem rather minute, the bearing of them all is important and too much rather than too little information is preferable.

CHAPTER VI

SILVICULTURAL SYSTEMS OF MANAGEMENT—FOREST RENEWAL

Silviculture is the art of reproducing and maintaining forests to get the best possible returns. The method of applying this art in securing continuous crops of timber is called a silvicultural system of management.

Forests may be reproduced either naturally or artificially. Artificial regeneration by means of planting, sowing, etc., is covered separately under Chapter VIII.

The objects of silviculture are to produce continuous crops of the best timber in the shortest length of time with the least consistent expense and without damage to the soil. The objects, however, may differ with the kind of ownership. For instance, private owners will naturally desire the best financial returns as a result of their forestry practice and have this one object in view, whereas public forests have a much broader function. Besides the yield of direct revenues in the form of saw logs, poles, ties, cordwood, etc., public forests, such as our State and National Forests, serve a very important purpose in equalizing the stream flow to prevent erosion and floods and in furnishing a steady supply of water for irrigation, water power, and municipal water supplies. Some forests, called protection forests, are maintained solely for these latter purposes. It is obviously impossible to measure in terms of dollars and cents the value of these functions. For this reason, too, the states and the Federal Government can afford to practice silviculture on the high mountains and poorer soils and leave the better soils for private interests which must secure as attractive financial returns from their investment as in any other business.

Trees vary so much in their characteristics and methods of growth, as explained in the chapter on silvics, that various systems have been devised to suit these differences in securing natural reproduction. Some trees, like yellow poplar and ponderosa pine, demand full light for growth; others, like beech, spruce, and hard maple, flourish in partial shade; some scatter their seeds readily in the wind; others grow in even-aged stands or in all-aged stands; hardwoods sprout up from the stump when cut; and so on. Each individual tree has certain characteristics which must be studied and determined before the most suitable system of reproduction can be chosen. Altogether the principal silvical characteristics which determine the method to be used in connection with a given tree are: (1) Relative ability to produce and scatter seeds. (2) Sprouting capacity. (3) Character of roots, or windfirmness. (4) Tolerance, or ability to endure shade. (5) Habit of growing in even- or all-aged stands. (6) Ability to grow in pure or mixed stands.

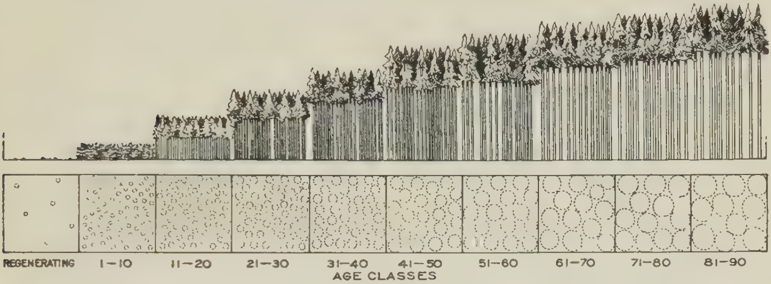


FIG. 49.—Diagram showing series of even-aged stands cut each 10 years according to 10-year age classes. For example, the trees on the right, 81-90 years of age, are ready to cut. The trees on the left have just been cut and the area is reforesting to new growth. Thus there is a constant succession of tree crops and the principle of sustained yield fulfilled. After U. S. Forest Service.

Methods of Natural Reproduction

There are three methods of securing natural reproduction, as follows: (1) By seeds. (2) By coppice or sprouts. (3) By root suckers. Of these reproduction by seed is by far the most important. Sprout reproduction is only used successfully with certain hardwoods in the East, and suckering is relatively unimportant and is not relied upon to reproduce our forests with any very important species.

By Seeds. Reproduction directly from seed is secured by leaving so-called mother trees, singly, in groups, or in strips, to reproduce a cut-over area. Most of our trees begin to produce seed when quite young and only scatter seeds every few years. For instance, Norway pine seeds every three or four years; white pine seed years occur six or seven years apart. Lodgepole pine begins to produce seed at six years of age and red spruce at fifteen years. The quantity of seed and the frequency of seed years depend on the amount of food material stored up in the trees. Therefore, trees seed less and more infrequently in the northern limits of their distribution, because the conditions of growth there are not so favorable. Light is the great single factor in seed production. Every one knows how full of seed a red oak or pine is when growing in the open. In dense stands, trees produce very little seed because each individual tree gets very little light. Trees under shade seldom seed. The best seed is produced when the energy of

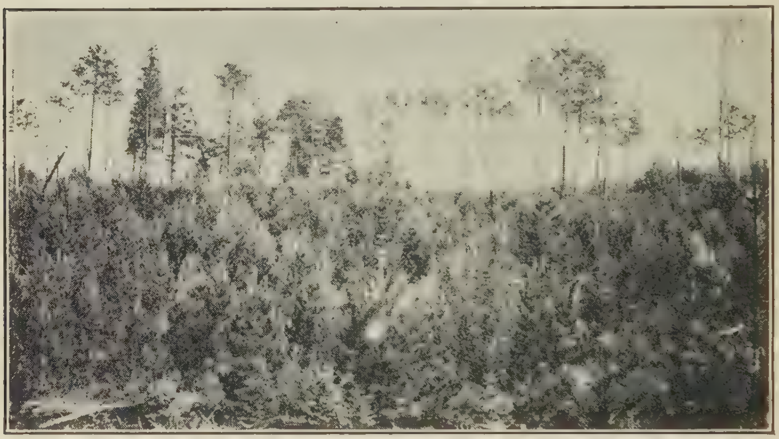


Fig. 50.—Excellent natural reproduction of Jack and red pine from seed trees on a burned-over area near Clear Lake, Minnesota. If sufficient "mother" trees are available, as shown in the background, many of these burned or logged areas may be seeded naturally and thus save the cost of planting.

the tree is greatest. This accounts for the fact that some seeds have a high percentage of germination, because they are taken from vigorous, healthy trees. Therefore, trees left for seed production should be young or middle aged, rather than old, defective specimens.

Seeds are dispersed in many different ways. Some are light; others are heavy. This is important in natural reproduction, because on it depends whether a system of clear cutting or gradual thinning can be adopted in renewing the stand. The principal means of distribution are wind, birds, animals, water, and gravity. Willow and yellow poplar seeds are light and are often carried a mile or more from the parent tree. White pine seed has blown one-half mile and given good reproduction. Heavy seed, such as the chestnut, hickory, and walnut, are scattered by such small animals as chipmunks and squirrels, and by rolling down slopes by force of gravity. Eastern red cedar and cherry are examples of species distributed by birds. Water often carries seeds great distances. Cottonwood and willow on the sand bars and banks of our rivers are often started from seeds carried downstream.

Many seeds are scattered, of course, that never germinate. It is estimated that millions of seeds are sown that never spring up, because insects and rodents destroy them or because they do not reach a favorable germinating bed. Some trees prefer a leaf mold or old rotten logs on which to germinate. This is especially true of hemlock and spruce. Others are partial to a mineral seed bed, as the Douglas fir and white pine. Some trees, as lodgepole pine and Jack pine, require a great amount of heat to open their cones. The grazing of sheep often stirs up the soil and assists the germination of seeds.

By Coppice or Sprouts. Sprouting is confined to the broad-leaved species, although pitch pine, shortleaf pine, and redwood often sprout after cutting or being killed by fire.

Most hardwoods, such as chestnut, the oaks, ash, and maple, sprout from dormant buds in the root collar, at the surface of the ground. Some, however, as poplars and willows, will often sprout from adventitious buds at the surface of the cut.

Sprouts are shorter-lived than trees grown from seed and after a certain age, usually forty years, their capacity to send out shoots rapidly diminishes. Sprouts grow much faster than trees grown from seed, because they have reserve energy in the form of food material stored up in the roots. Chestnut is our best sprouter and will often shoot up 8 to 10 feet the first year after cutting. It will produce telephone poles and cross ties in forty years and good-sized saw logs in fifty years. Sprout stands are usually managed, however, on short rotations up to thirty or forty years to produce fuel, fence posts, rails, and other small materials. Catalpa will often shoot up 10 to 12 feet in one year when cut back. This gives a tall, straight growth.

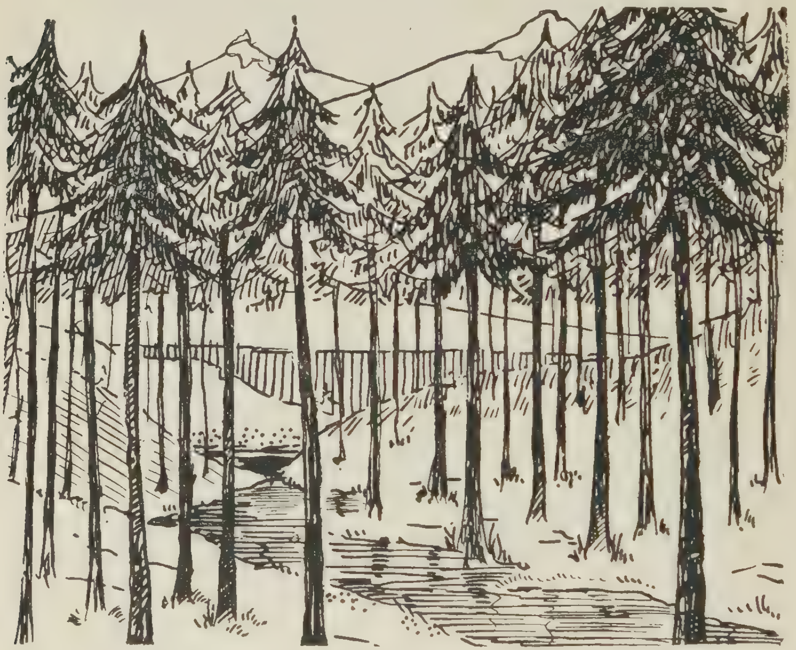


Fig. 51.—Single-storied, well-stocked, and even-aged stand. Trees have fully developed, thrifty crowns; stems are clean of limbs, in good condition, and growing at a good rate of value and volume increment. The best and thriftiest trees, well-spaced, should be selected for the final stand, perhaps 200 to 400 per acre, and crown competition should be relieved by careful thinning.

Eucalyptus sprouts have, in exceptional cases, reached a total height of 60 feet in ten years.

By Root Suckers. Shoots from the roots of trees are called suckers. Some species sucker when apparently in good health; others, as elm, basswood, and sycamore, send out shoots from the roots only when wounded. Beech and aspen are, perhaps, our best examples of root suckering. In fact, in certain regions reproduction is almost wholly secured by this method. As a general method of reproduction, however, suckering is relatively unimportant and it is doubtful if it will enter into forestry as a means of renewing the forests on a commercial scale. Practically all aspen stands are reproduced by suckering.

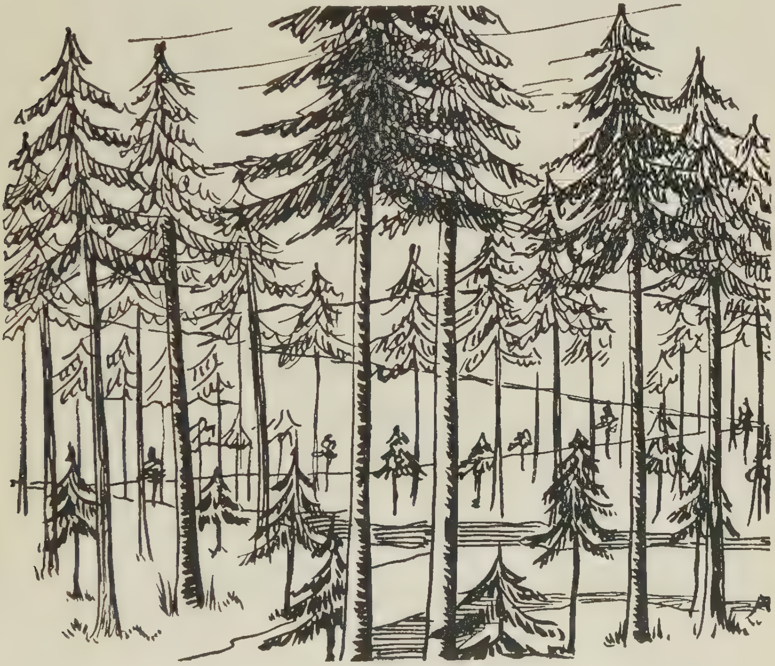


FIG. 52.—Two-storied stand with dense crown canopy and sparse reproduction (understory). In young stands the overwood should be thinned; in mature stands, the largest trees cut for saw logs and the underwood given opportunity to grow more rapidly.

tificial — planting — sowing.

Natural Versus Artificial Reproduction

The question of securing reproduction of forests by natural means or by planting or sowing has always been a very important one in forestry. Much can be said in favor of each method, but the local conditions will be the determinant factor in each case. In Europe, where forestry has been practiced for three to four hundred years, artificial regeneration is the principal method employed, especially where the most intensive practices may be followed. There is, however, a growing ten-

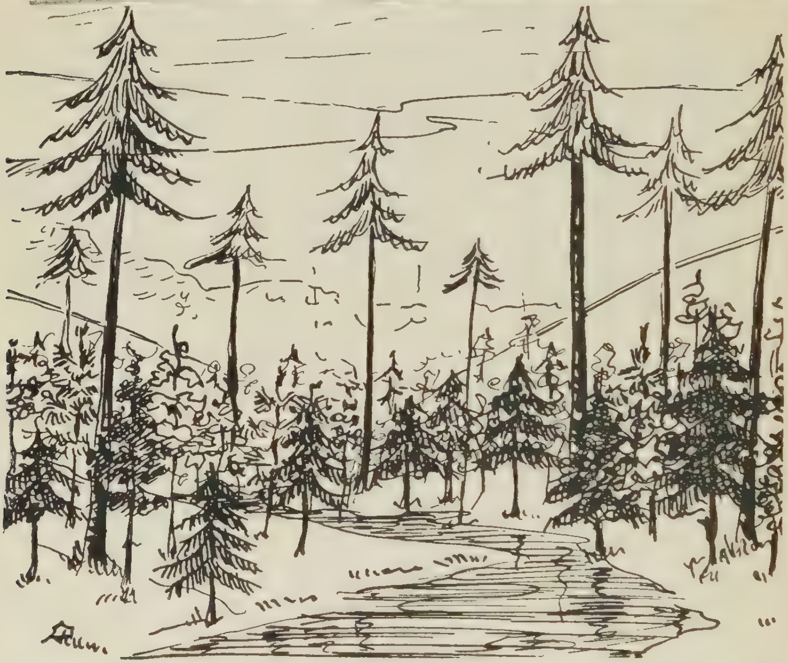


FIG. 53.—Two-storied stand with dense underwood and sparse overwood. From 6 to 40 trees per acre are in the overwood or upper story. From 500 to 10,000 or more seedlings and saplings per acre are in the understory. The larger trees are insufficient to justify profitable logging at present. The poorest of the upper story should be removed, the understory cleaned and thinned, and the best trees, perhaps 200 to 400 trees per acre, be slected for the final stand. Liberation cuttings are made if the larger trees are competing with the young ones for the crown and for root space.

urope uses artificial method.

dency even in Germany and France to follow nature more closely. It may be said, nevertheless, that in this country it will be many years before planting will be resorted to on a large scale, because it is comparatively expensive, costing from $6 to $15 per acre at least. In addition, many of our species are adapted to regeneration by natural means either through sprouting from stumps or the distribution of seeds. White pine in the Lake States and Northeast, loblolly pine in the South, lodgepole pine in the Rocky Mountains, and Douglas fir in the Northwest are splendid examples of trees that reproduce themselves naturally and successfully from seed. Wherever forests have been denuded by lumbering and then burned by disastrous fires, the only practical means to employ is planting. New York has already planted about 400,000 acres on state and private lands. The United States Forest Service reforests about 1,000,000 acres annually by planting and seeding.

Advantages of Natural Reproduction. The great argument in favor of natural reforestation is its cheapness as compared with artificial methods. The only cost involved is in the leaving of seed trees individually or in groups or strips. These may be a few thrifty growing or old, defective trees, so that this investment may be almost negligible. Natural reproduction also follows nature more closely, and the kind or mixture of trees best suited to the locality is the result or can be easily secured by proper thinnings. There is apt to be less washing of the soil and exposure to the elements, because with most of the methods of natural reproduction the ground is protected by at least a partial forest cover. Then, too, in this country where intensive forestry will not be practiced until our virgin forests are more completely cut over and market conditions improve, natural reproduction can best be practiced, especially in our rough mountains and remote forest areas.

Advantages of Artificial Reproduction. As opposed to the above, the following is a summary of the advantages of establishing and renewing forests by artificial means:

1. Reproduction is secured immediately. Seed years are

Natural method is cheaper

Best argument ↑

often far apart, and natural reproduction may require a number of years to cover satisfactorily the cut-over area.

2. It is sure, provided proper methods and species suited to the soil and climate are used.

3. The best trees suited to the local market may be used. Sometimes species not naturally growing in the locality may be planted with success.

4. Each tree is given the proper space for growth, which in the end means a greater and better product.

The Cost of and Returns from Silvicultural Practice

It is obvious that the practice of silviculture is more expensive than the old method of lumbering in this country, which had no thought of the future. In order to be practicable, therefore, silviculture must insure in the long run an adequate return on this increased investment. Perhaps this can be best explained by a comparison of wood production in this country and abroad. Under our present haphazard system of careless cutting, enormous fire losses, and improper care of our growing forests, it is estimated that on an average only 12 cubic feet of wood are produced per acre annually in this country. Contrasted with this, the annual production of wood in Germany is over 48 cubic feet per acre. In other words, it has been very profitable for Germany to engage in the intensive practice of silviculture. Their economic conditions are responsible in a measure for this, but they do not in themselves explain this wide discrepancy.

The added costs that are usually involved in practicing silviculture may be briefly enumerated as follows:

1. Increased cost of logging in removing only a portion of the stand at a time and in protecting young growth from injury.

2. Cost of marking trees for removal.

3. Value of mother trees left for seeding purposes.

4. Cost of supervision and protection from fire, such as brush burning, patrol, etc.

It is apparent that the cost of these operations will vary greatly according to the silvicultural system employed, and the local conditions, such as the markets, cost of labor, type of forest, method of logging, etc. For a lumberman to employ fairly intensive management, the increased cost would be between 50 cents and $4 per m.b.f. logged. This cost would be distributed about as follows: Fire protection and supervision would cost annually about 2 to 7 cents per acre; brush burning, if used, about 25 to 75 cents per thousand; cost of securing reproduction from $2 to $8 per acre and increased cost of logging from 20 cents to $2 per m.b.f.

The returns, on the other hand, will also vary greatly. The forests of one of the German states have averaged as high as $5.40 net per acre per year. Some of the famous municipal forests have yielded $7 per acre per year. In New England, white pine plantations have yielded as high as 6% on the original investment, even under our comparatively unfavorable market conditions. Some Middle West plantations have brought an annual return of over $10 per acre per year with catalpa, white pine, and cottonwood. Several of our states are purchasing large areas of cut-over or second-growth forests, which will no doubt pay good returns as a long-time investment. Ordinary forests in this country may be made to yield at least from $1 to $4 per acre per year. This can be done on soils that are unsuited to agriculture and would otherwise be unproductive waste land. With improved market conditions and better methods of logging, the returns in the future are sure to be even greater.

Silvicultural Systems of Natural Reproduction

The following systems of reproducing the forest by natural means are generally recognized:

1. Selection system.
2. Clear-cutting systems.
3. Shelterwood system or stand method.
4. Coppice, or sprout, system.

Each of these systems is carried out in practice with a great

Selection
Clear cutting
Shelter [illegible]

many variations to suit the local requirements. Under intensive practice the forest type is the basis of managements. The type may extend over a few or many hundred acres. In any case, the whole tract is usually subdivided into compartments, and each compartment is cut over annually or periodically so that there is a continuous yield. For instance, if a tract of white pine is to be managed on a rotation of 100 years and a portion of it is to be cut each year, there will be 100 compartments. Thus, when the last compartment is cut over, the first one will have reached maturity and will be ready for the axe. If, on the other hand, it is planned to make a cutting only every five years, this area would be subdivided into 20 compartments.

Selection System. Under the selection system the trees are removed individually or in groups as they reach maturity, and there is a gradual succession of young trees growing up to take their places. This is the popular idea of the means that are employed to keep our forests in a continuously productive state. With our rough and extensive system of forestry in this country, the selection system is easily applied and requires less skill than any of the others except the coppice system. Many of our lumber companies employ it in a rough way in

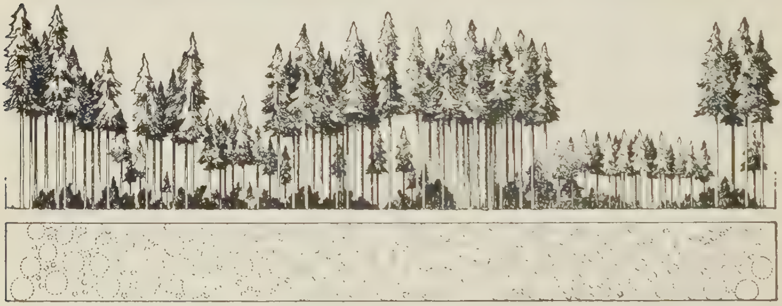


FIG. 54.—Diagram illustrating a selection forest containing trees of all age and size classes. This type of forest lends itself admirably to selective logging, whereby the larger trees of profitable size are removed and the residual stand left for later growth and cutting. After U. S. Forest Service.

taking out of the woods only the larger and finer specimens of merchantable trees. It is the method principally employed up to the present time on our National Forests, because market conditions do not often permit the use of the clear-cutting or shelterwood systems. It is also best used in our woodlots, where the larger trees can be cut from time to time and the smaller ones left to grow up and develop, while seedlings take the places of those removed.

This system, however, is only applicable to stands where all-age classes are represented (selection forests). That is, if a cut is made every ten years on a rotation of sixty years, there should be at least six distinct age classes represented. This distribution of age classes must be maintained, because only the periodic or annual growth should be cut, and it is necessary to have the requisite number of young trees growing up to fill the places of those removed at the time of cutting. For example, on a tract of 1000 acres, if the annual growth of all the trees is found to be 500 b.f. per acre, this amount could be removed annually per acre, or 5000 b.f. per acre every ten years.

A rough method commonly followed to regulate this yield is the use of the diameter limit. That is, all trees above a certain minimum diameter are removed unless needed for seed purposes or to protect the soil from erosion. This method is especially useful in placing a virgin forest under at least some rough system of sustained yield. In the West, lodgepole pine is often cut to a diameter limit of 12 inches; ponderosa pine to 18 inches; and Engelmann spruce to 14 inches. In the East, spruce is cut to 8 inches for pulp wood; hardwoods, such as beech, birch, and maple, to 15 inches; hemlock to 14 inches, etc. Certain undesirable species in the stand can easily be discriminated against by reducing the diameter limit for them so that, through repeated cullings, they will be eliminated in favor of better species.

In addition to being applicable to selection forests (stands of all-age classes), this system should theoretically be used with tolerant and windfirm species. Where all ages are represented, the young trees will have to come up under partial shade at least, and when the large trees are removed it opens up the stand considerably and many trees are likely to be thrown over by the wind unless they are deep and strong rooted.

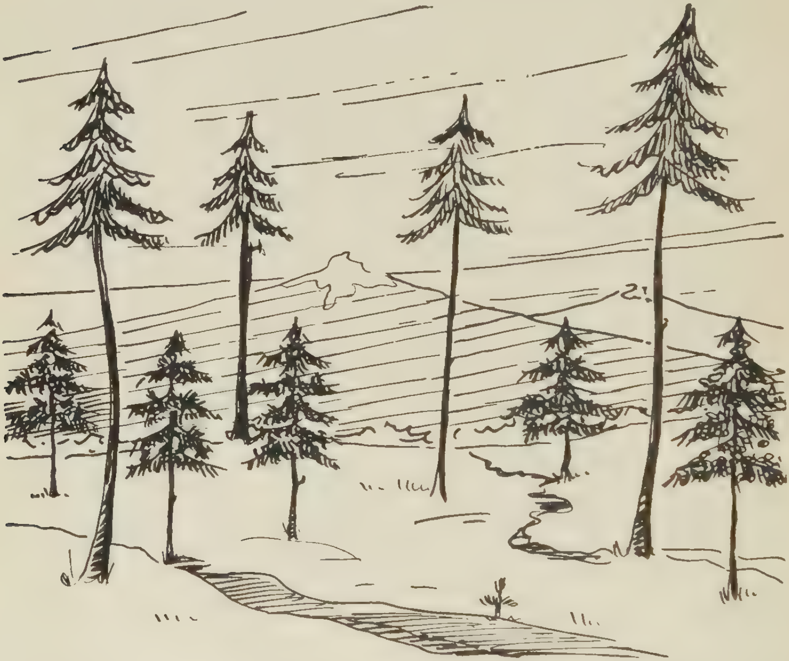


FIG. 54-A.—Two-storied stand poorly stocked with insufficient trees in both underwood and overwood. This condition needs restocking. Neither story is dense enough to maintain proper balance in both crown and soil competition. If of intolerant species, the overstory may be cut. If natural reproduction is favorable, they may be left for seed trees. Planting should be used to restock the area if economically possible. This condition may be the result of overgrazing, burning, or improper methods of cutting, or all three.

Whenever a selection forest contains different age groups instead of individuals, tolerance and windfirmness are apparently not so important. Ponderosa pine in the Southwest, an intolerant tree, is a good example of management by the group selection method.

The advantages of the selection system may be summed up as follows:

1. It is easily applied to virgin forests and tracts where only rough forestry is permissible and only the largest and best individuals can be marketed at a profit. Little skill is required.
2. It maintains the forest cover and therefore prevents erosion and floods.
3. It is inexpensive. The only added cost is slightly more expensive logging and the cost of marking trees for cutting, which is only about 3 to 10 cents per m.b.f. marked.

Clear-cutting Systems. With this system the forest, or a portion of it, is cut clear. There are a great many variations of this system. Reproduction may be secured from adjacent forests or from seed trees left standing in the area logged either individually, in groups, or in large blocks. It is principally applied in Europe by cutting consecutive narrow strips each year or periodically, against the direction of the prevailing wind.

The conditions that require the use of the clear-cutting methods are:

1. Where trees are shallow-rooted or grow in exposed places and there is danger of their being thrown by the wind. Examples: red spruce and white cedar.
2. Where trees grow in even-aged stands so that logging can be done most cheaply by removing the whole stand, and whatever reproduction is present cannot be protected. Examples: Douglas fir, redwood, and white pine.
3. Where trees are intolerant of shade and need full light for reproduction. Examples: western white pine, western larch, and southern cypress.
4. The use of light-seeded species, such as pines, spruces, yellow poplar, etc., the seed of which can easily be carried by the wind.

Conspicuous examples of the use of clear cutting in this country are Douglas fir in the Northwest, lodgepole pine in Montana, western white pine in northern Idaho, and red spruce in

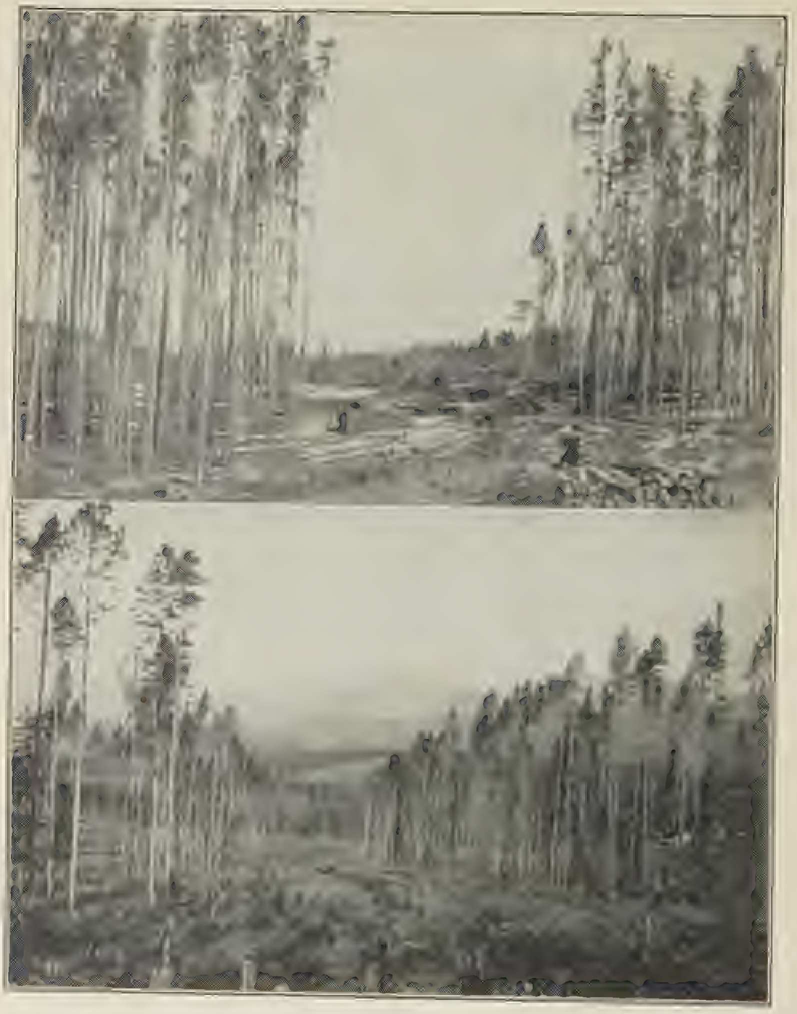


FIG. 55.—Two views showing systems of clear-cutting, the upper view shows the block system the lower one shows the strip system, in lodgepole pine on the Deerlodge National Forest, Montana. They illustrate some of the many experiments that have been tried in the development of American silviculture. Neither the block nor the strip system has proved to be successful. A system of selective logging has proved to be better because the trees left in blocks or strips, as shown in these pictures, are easily wind thrown and do not scatter the seed on the logged area as satisfactorily as expected.

the Adirondacks on exposed situations. On the Deerlodge Forest in Montana, lodgepole pine seed trees have been left singly, in groups, and in strips. Reproduction with this species is so thrifty, when the soil is burned over to open the cones and prevent fire danger, that the young trees often come in too dense for best development. Of this forest clear cutting is advisable, not only on account of the silvical characteristics of lodgepole pine, but also on account of the market conditions. The Butte mining district uses not only saw logs and mining stulls but also enormous quantities of mine props and lagging and fuel wood, so that there is complete utilization of all available material logged from the forest.

Leaving white pine seed trees scattered over the lumbered area has been tried in Minnesota, but the isolated seed trees were blown over by the wind. This system was also unsuccessfully used with western white pine in Idaho, but by leaving large blocks or groups of seed trees, for mutual protection, this difficulty was avoided and excellent reproduction secured. These blocks were located on ridges and vantage points to obtain the best seed distribution. Ridge-top trees are generally more windfirm.

The yield may be regulated in the same way as explained in connection with the selection system; that is, only the growth is cut from time to time.

The brush and slash after logging is disposed of either by piling and burning the brush or by burning it broadcast. This is done both to reduce the risk from fires and to expose the mineral soil so that the seeds may germinate more easily.

The advantages of any of the adaptations of the clear-cutting systems have been briefly mentioned above. The disadvantages are as follows:

1. Clear cutting exposes the soil and leaves it susceptible to deteriorating influences, such as erosion, baking of the soil, loss of humus, and occupation of the soil by grasses, weeds, etc.

2. The young trees are exposed to damage by insects and frost and drying by wind and sun.

3. It is only applicable to light-seeded, intolerant trees that grow in even-aged stands and, under certain conditions, trees that are windfirm.

It may be added, however, that the disadvantages of clear cutting may be minimized by cutting very small areas or narrow strips at one time. The larger the areas cut, the greater are the dangers and likelihood of securing unsatisfactory reproduction.

Shelterwood, or Stand Method. This is a highly theoretical system of management and will not be used, except in a very rough way, for a long time in this country. It is seldom used even in Germany and France, and demands the most favorable economic conditions for its successful application.

It is a system of management whereby reproduction is secured by means of a systematic progression of thinnings. It it applicable only to even-aged, tolerant species that are windfirm.

At first the shelterwood system involved the use of only two general thinnings or openings in the stand to secure reproduction. The following three are now used when the system is intensively applied:

1. *Preparatory Cuttings.* These are begun during the middle of the rotation and open up the stand, by the removal of a few trees (from 15 to 35 per cent), to prepare the soil for the germination of the seeds, to stimulate seed production by giving more light to the intended parent trees, and to accustom the remaining trees to more or less isolation and give greater windfirmness. If the stand is dense, this thinning should be made much heavier than in a thin or open stand.

2. *Seed Cutting.* This consists of one or more thinnings a few years later, to open the stand still further, and is usually done just before or during a seed year. This removes from 30 to 60% of the remaining trees and has its object the opening of the stand so that the young reproduction resulting from this seed year may develop in the spaces and light made by the thinnings.

3. *Removal Cuttings.* All the remaining trees may be removed in one or more cuttings. By this time the reproduction that will form the next rotation is well under way and needs all the light possible for full development.

These three groups of thinnings or cuttings may be carried on over the whole stand periodically or may be developed gradually over the forest by means of strips or groups.

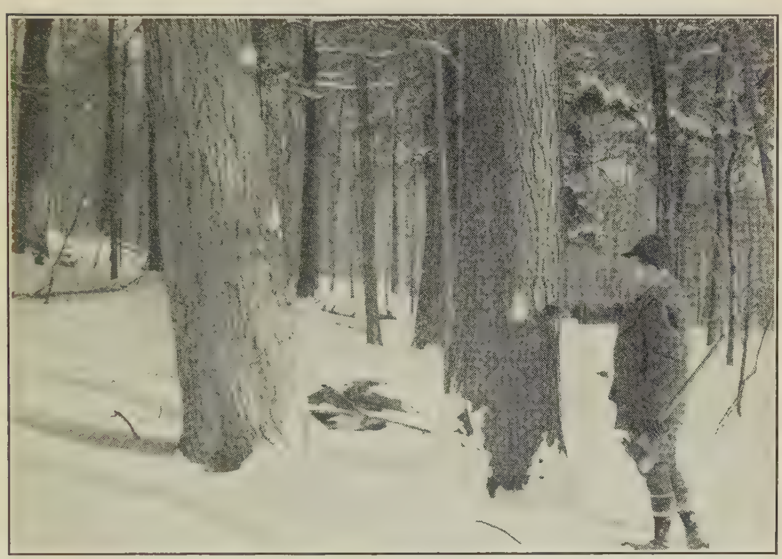


Fig. 56.—A forest ranger pointing to a hemlock tree that has been marked by a blaze for cutting in the Alleghany National Forest of Pennsylvania. Marking is frequently done in the winter by men on snowshoes.

The shelterwood system is used in a very crude way in the Black Hills with ponderosa pine, with eastern red spruce, with lodgepole pine, and with longleaf pine.

The advantages of the system are as follows:

1. The progressive thinnings leave a large number of seed trees evenly distributed.

2. This system does away with most of the disadvantages of the clear-cutting systems since the soil and reproduction are not exposed in any way.

3. The new stand is established in advance of the final cutting, and the thinnings give the maximum rate of growth to both young and old trees.

4. The system may be used with heavy-seeded species.

5. Trees not desired in the new stand can be eliminated in the preparatory cuttings.

The disadvantages are as follows:

1. It requires considerable skill and the best possible market conditions in order to dispose profitably of the product of the thinnings and final cuttings.

2. Logging is very expensive as the forest is worked over so many times in cutting off the trees.

3. Reproduction is exposed to serious injury both in falling the trees, in thinnings, and in removing them from the forest along skidways and roads.

4. Theoretically it should not be used where there is danger from windfall or with intolerant speecies.

Coppice or Sprout System. This is the simplest method of securing natural reproduction. Because of the excellent sprouting capacity of most of our hardwoods, the forest may be reproduced by merely cutting off the trees at maturity. This system has been used for many years in parts of New Jersey, Pennsylvania, Connecticut, and southern New York, to supply some of the smaller products of the forest, such as cordwood, poles, posts, ties, and mine timbers. The old stumps, however, deteriorate after a certain number of rotations, and the forest must be renewed from time to time from seed. This has already happened in some parts of the East. In Europe there is a growing sentiment in favor of the increased use of seedlings in sprout forests. In fact, even in the first rotation of management under this system, most hardwoods lose their maximum sprouting vigor after a certain age. This limit is about 25 years with nearly every species, except chestnut, which apparently retains this power for a much longer time. Vigorous chestnut trees have been produced from stumps 120 years of age. Some trees fail to sprout after 40 to 60 years of age.

In Europe, sprout forests are often cut on rotations of 10 to 20 years to produce fuel wood.

There are certain rules which should be observed in cutting trees to obtain the best sprouts, as follows:

1. Trees should be cut between October 1 and April 1, during the period of vegetative inactivity. In the spring, the new shoot will often grow up to a height of 8 to 10 feet. If cut in the summer, sprouts are still weak when winter comes and are likely to be winter killed or seriously injured by the cold.
2. Stumps should be cut low in order to make the sprouts as vigorous as possible. Decaying stumps often infect or interfere with the growth of the new tree. More valuable wood can also be secured by cutting low stumps.
3. Stumps should be cut smoothly and sloping, so that water will run off and the danger from insects and fungi will be decreased. The bark should also be left intact for the same reason.
4. A given area should be cut clean in order to give the greatest amount of light to the young trees, and brush should be piled away from the stumps.

Variations in sprout management in leaving certain sprouts and seedlings over for a second rotation are sometimes used, especially to rejuvenate the stand by increasing the number of trees from seedling origin. When this is not successful, planting must be resorted to.

The region of best sprouting in this country is along the Atlantic Coast, east of the Appalachian chain of mountains, from Maryland north to Massachusetts. The best tree for sprout management is undoubtedly chestnut, on account of its sprouting capacity, rapid growth, and the excellent quality of its wood. Unfortunately, the bark disease may eliminate it from future management. Other important trees that sprout to advantage are the oaks, hickory, basswood, yellow poplar, red maple, and white ash.

Combinations of Silvicultural Systems

It is seldom that the silvicultural systems, depending on natural reproduction from seed, described above, are followed out in this country according to theoretical principles. Very often local conditions, such as markets, topography, type of timber, etc., make many changes necessary. Frequently combinations of various systems are employed. Natural reproduction is often assisted by planting young trees or direct seeding to fill in the open spaces where the expected reproduction has not seeded in naturally. In Europe, in fact, planting is resorted to in the majority of cases where clear cutting is used.

Factors Governing the Choice of Species for Management

In choosing the proper trees to favor in the management of any forest tract, there are several considerations which must be kept in mind:

1. The most important is rapidity of growth. A certain tree may yield a wood of high technical qualities, but if it requires two or three hundred years to reach merchantable size, this will discredit it. Some of our redwoods are three thousand years old. Longleaf pine and southern cypress, although producing excellent woods, are too slow in growth. Chestnut, red oak, Douglas fir, and white pine are rapid growers.

2. Quality of wood is apparently very important. If two trees of equal rapidity of growth are of unequal demand on the market, the better one should be favored.

3. Reproductive ability is important. A thrifty and easy seeder should be preferred to a tree of infrequent seed years, low percentage of germination, and one whose seed is distributed with difficulty. Some trees are also planted much more easily than others because of their small root systems.

4. Silvicultural value is also a consideration. Some trees help the growth of others in association with them and improve the quality of the soil. Beech, for example, is sometimes called the " mother of forests."

5. Freedom from injury by wind or attack by insects and

fungi must be considered. In some localities the borer attacks the black locust so seriously that this species cannot be encouraged with safety. The example of the chestnut blight is also self-evident.

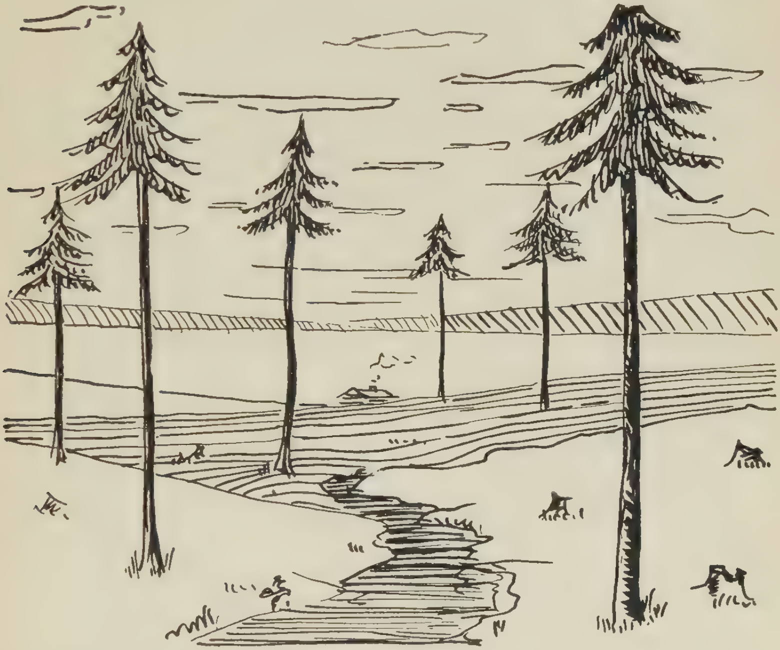


FIG. 57.—Seed trees left after logging, to reproduce naturally the cut-over area. Usually one to ten trees per acre are left for seeding purposes. The best, most thrifty, and vigorous trees should be left for seeding to reforest the area naturally, or it should be replanted at once.

6. Suitability to the local market is important. For instance, where mine timbers or cooperage stock or any other special forest product offers a good market, it may be advisable to grow trees that will be most suitable for this demand.

Altogether some of our best native trees for encouragement in American silvicultural practice, based on the above considerations, are white pine, Norway pine, Douglas fir, slash pine, loblolly pine, shortleaf pine, western white pine, ponderosa pine, sugar pine, chestnut, red oak, basswood, yellow poplar, white ash, and cottonwood. Some of the best exotic species for use in this country are Scotch pine, Norway spruce, European larch, and eucalyptus.

CHAPTER VII

CUTTINGS AND THINNINGS TO IMPROVE FORESTS

Reasons for Improvement Work

While nature, unassisted, provides splendid stands of timber after a lapse of centuries, economic forestry requires maximum production of timber in the least possible time and with minimum expense. Consequently, all measures should be taken that will improve the quality of timber, shorten the rotation, and diminish the necessary charges, considering the forest soil and crop as an investment. With these ends in view, certain improvement work is imperative under average conditions, since the expenditure of a little money will often prove a splendid investment, by largely increasing the returns. The removal of undesirable species and weaklings, with consequent diminution of competition, results in increasing the volume growth and vastly increasing the quality and yield.

Kinds of Improvement Work

Cuttings made in immature stands of timber for the purpose of accelerating growth, diminishing competition, or improving the mixture are of prime importance. The starting of new growth is not aimed at primarily in making these cuttings, although a heavy thinning in a forest old enough to produce seed may often result in a dense stand of seedlings beneath.

Improvement cuttings may be classified under four heads:

1. Cleanings (Weedings).
2. Liberation Cuttings.
3. Thinnings.
4. Damage Cuttings.

Cleanings. A cleaning is a cutting made in a very young stand to improve the mixture and reduce competition. Such an operation hardly ever yields a profit, but ordinarily requires the expenditure of from 50 cents to $2.50 per acre. Therefore, a cleaning is warranted only under conditions where intensive forestry may be practiced.

Cleanings are needed where desirable species are being badly crowded or suppressed by fast-growing forest weeds, and the object is to keep the desired species in the mixture by cutting back the weeds and releasing the slower-growing seedlings which will ultimately yield timber of higher technical value. Such a condition is often found in the young sprout stands where species like basswood, ash, red oak, etc., are being rapidly choked out by such strong sprouting species as black oak, aspen, maple, etc. In such circumstances, a few hours' work per acre may result in a vastly improved stand of timber. The seedlings in each case are favored at the expense of the sprouts.

Fig. 58.—White pine reproduction established by cleanings under a defective hardwood understory as a result of protection from fire. Release of such desirable understory trees of various species is one of the chief silvicultural problems of the Southern Appalachians. Cherokee National Forest, Georgia.

In many New England pastures which have seeded in to gray birch, pine or spruce often comes in under the nurse trees. As the stand grows older, the injurious effects of the birch become more and more apparent. At the beginning, the light shade was an advantage in preventing the drying out of the soil, but, as time passes, the top shoots of the pine and spruce become enmeshed in the branches of the birch. It is very common to have the leaders and side branches of the conifers badly damaged by the whipping action of the birch. This whipping action may be so marked that large holes will surround each birch in a dense stand of pine. In such circumstances, a cleaning during the early life of the mixture would have improved the stand and greatly reduced this damage.

Cleanings are also required where a plantation has been made beneath dense underbrush, such as a stand of sumach or scrub oak. In the scrub oak country of Pennsylvania, or Long Island, where the ground is practically in possession of this tree, it would be necessary to clean the land before planting, and then carefully watch the plantations to see that the seedlings are not crowded out. A brush hook, machete, or light axe is the best tool for cleanings; although, in young sprout stands, heavy pruning shears may work well. In some cases, the expense may be decreased by hacking off the top of the undesirable specimens rather than cutting them off flush with the ground.

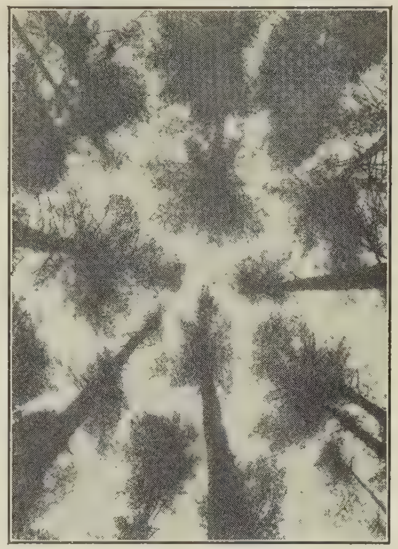


Fig. 59.—Looking up from the forest floor about 100′ into the canopy of a Douglas fir stand. If natural stands or plantations are thinned properly they may yield 100% more than unthinned stands. The skillful art of thinning is a very important part of forestry. Photograph taken in southern Washington by S. O. Heiberg.

Cleanings should be made in young stands as soon as the crowding effects are noticed. Usually, in a mixed stand, this will occur during the first ten years. If economic conditions warrant it, a light cleaning should be made, and repeated within five years.

The most important point regarding cleanings is to decide whether or not conditions will justify the expenditure, and how much should be taken out. When it is realized that in a stand of young sprouts and seedlings the investment of $2 to $3 per acre — the labor cost of cleaning — may free 300 desirable seedlings five years old, and that this number will more than fully stock the stand at maturity, it may be seen that cleanings are often highly profitable.

Liberation Cuttings. Where an abandoned pasture has seeded in, it is quite common to find occasional large trees scattered among the young seedlings which form the majority of the stand. As the seedlings develop, the shade cast by the advance growth becomes more injurious, and the young tree may be throttled by the larger trees, which accounts for the name "wolf tree," coined by the German foresters. In addition, the excessive root competition of these large spreading trees often makes profitable growth of young seedlings impossible within a wide radius. In such circumstances, the removal of this advance growth is necessary, in order that a full stand of straight, desirable saplings may result.

Unlike cleanings, liberation cuttings may be quite profitable, since large trees are removed and, consequently, good timber may be obtained. The quality, however, is often poor on account of the presence of many knots, and the scattered trees make logging costly. A liberation cutting should at least pay expenses.

The trees removed are, for the most part, much older than the seedlings which they are damaging, and this difference in age constitutes a distinguishing feature. For this reason, less skill is required in selecting the individuals to be cut, and liberation cuttings may, as a rule, be carried on independently of other cultural operations.

Thinnings. By thinning is meant the removal of individuals in an immature stand which is too dense for rapid growth, in order to diminish competition for light, food, and moisture. The fastest-growing individuals of the best form are favored and dissipation of growing energy is prevented. The result of a thinning is to shorten the struggle for existence. By focusing all the growing energy that the site affords upon a few selected individuals, much greater volume growth is obtained, and the quality increment is much higher.

Reasons for Thinnings

With increasing age, each tree in the stand demands more room both for crown and roots, which results in excessive competition for light and plant food. Under nature's régime, this struggle is prolonged and the trees which have been leaders from the beginning gradually surpass their slower-growing neighbors and eventually appropriate the space which the latter once occupied. Close planting or a dense stand is necessary for a time in order to cause natural pruning. Indeed, the German foresters insist upon it in order that the early growth shall not be too fast and therefore sacrifice strength. After a few years, however (ranging from fifteen to twenty-five, depending on the species and site), interference in the form of a thinning is advisable. In a dense stand, even the dominant trees do not grow at their maximum rate, and by relieving the desirable trees from excessive competition, the growth rate is vastly increased.

Improvement cuttings in immature stands have the following beneficial results:

1. They tend to shorten the rotation. Whereas a stand of sprout hardwoods will ordinarily yield trees 10 inches in diameter in forty years if untouched, the same forest properly thinned, will produce trees the same size in thirty to thirty-five years.

2. A large amount of material is utilized which would otherwise decay and be a total loss were the usual struggle allowed to proceed. By utilizing the young saplings for fuel, posts, bucket stock, etc., when they are green, the material can oftentimes be profitably sold; whereas, if they were allowed to remain, the quality would be greatly damaged through insect and fungus attacks. The amount of material removed by thinning during the life of the stand may constitute from 20% to 60%

of the final yield and this "intermediate yield," so-called, may often determine whether or not the stand itself is profitable. Indeed, in the Duchy of Baden, extremely heavy thinnings are advocated to reduce the amount of forest capital invested, as a means of increasing the financial profits. The intermediate yield, in this case, is necessary, not because of silvicultural requirements but because too much timber capital is involved.

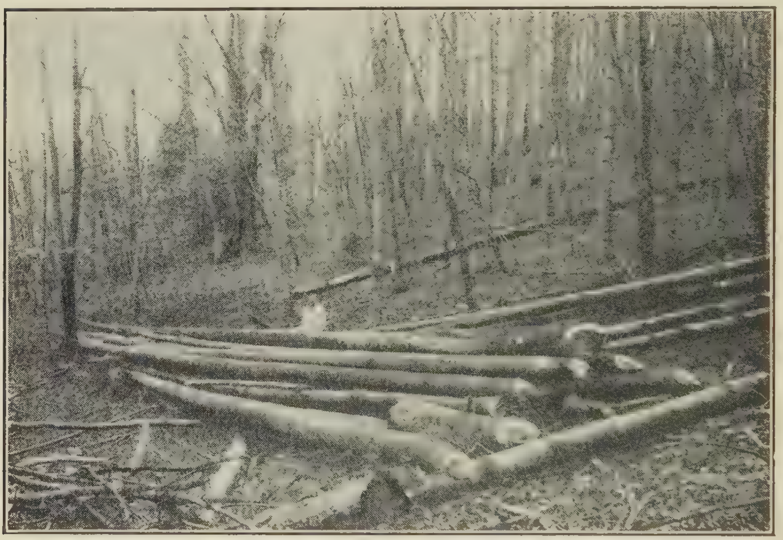


FIG. 60.—Class of material removed from thinning a yellow poplar stand. Merchantable portions of the trees are skidded to a yard at the foot of the mountain and sawed into 5′ pulpwood bolts. Cranberry, North Carolina.

3. The removal of the competing trees does not decrease the final yield; on the contrary, it is increased, considering the increased growth rate. The quality also is greatly improved.

4. Because of the discrimination against undesirable species, the stand at maturity will contain the species in the proportion desired. This is particularly desirable where natural regeneration is practiced, as each succeeding rotation requires less cultivation.

5. In stands which have been consistently thinned, windthrow and breakage from wind are lessened, owing to the

fact that the individual trees have had greater opportunity for root and bole development. Consequently, the individual trees are much stouter and stronger and are able to resist the force of destructive winds.

Severity of Thinnings

Severity of thinnings largely depends on the product desired as well as the condition of the stand itself. The danger from windfall also may be so excessive that thinnings in older stands must be avoided altogether. Ordinarily, even if the species is not windfirm, by thinning early, lightly, and often, a firm root habit may be developed.

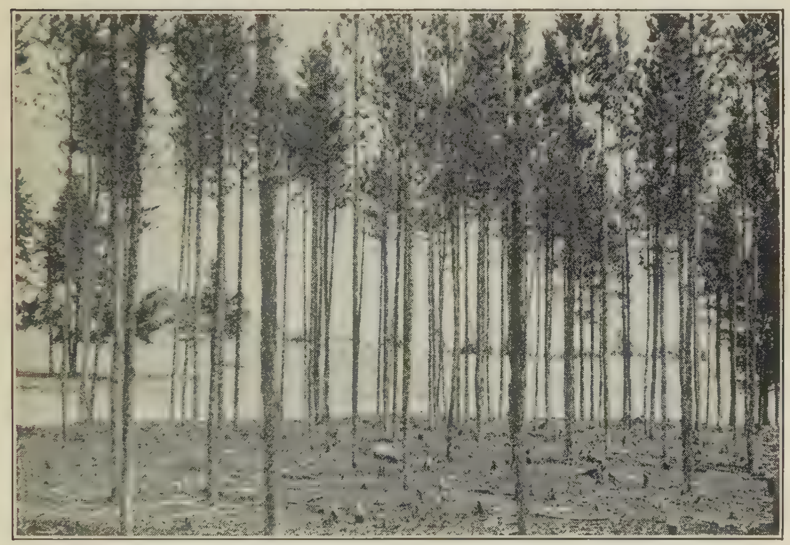


FIG. 61. An improvement thinning made in lodgepole pine by men of the Civilian Conservation Corps on the Big Horn National Forest, Wyoming.

If maximum volume production is desired, heavy thinnings are the rule. If timber free from knots and of good technical value is aimed at, moderate thinnings should be made at frequent intervals.

The severity of thinning is measured by the amount of timber removed, and the size of the holes made in the canopy. It is a safe guide, as a rule, to make no holes in the canopy that the trees cannot fill by crown growth within five years. In some cases this is unavoidable; but, if too heavy thinnings are made, the soil is exposed to the drying effects of sun and wind, weeds and grass spring up and exhaust the soil, and instead of being increased the growth rate may ultimately show a decrease. Thus, too heavy thinnings are apt to defeat the end in view.

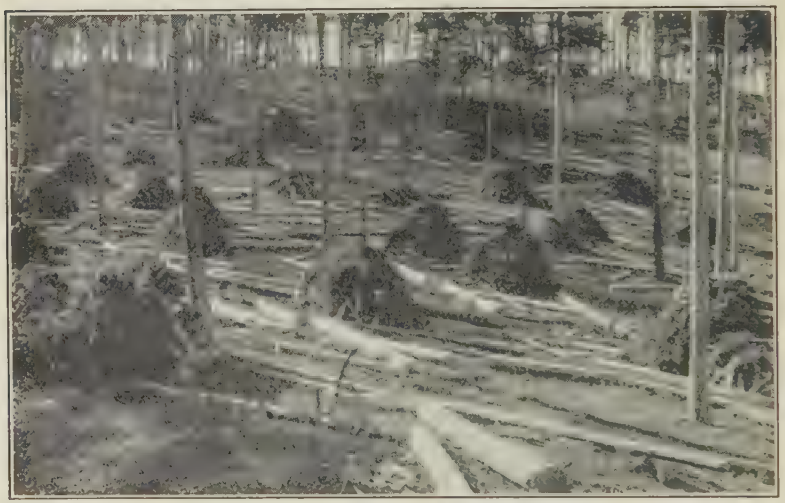


FIG. 62.—A typical logging scene in the ponderosa pine stands of the Black Hills National Forest of South Dakota. The larger, mature trees are cut by a method of selective logging, leaving the young and immature trees in the residual stand to produce crops for the future. Slash is piled ready for burning to reduce the fire hazard. Many million board feet are cut each year on our National Forests.

In addition, with hardwoods, increased light may cause the sprouting of adventitious buds along the trunk, producing a brushy bole and diminishing the amount of clear lumber that may be later obtained.

The severity of thinnings is graded as follows: (See tree classes, Chap. V.)

Grade A. Light, removing dead or dying trees.

Grade B. Moderate, removing all suppressed, and in addition the lower intermediate trees.

Grade C. Heavy, removing in addition the remainder of the intermediate trees.

Grade D. Very heavy, removing in addition many of the codominant trees.

A heavier thinning than any of the above is called an accretion cutting. A cutting of this kind is rarely made in American forestry practice, although the same end may be gained by starting reproduction cuttings (see Chapter VI under Shelterwood System), rather early and permitting the seed trees to profit by the increased light. In some parts of Europe this has been carried to extremes, as the highly profitable growth made by the seed trees led the foresters in charge to hold them over to the injury of the reproduction.

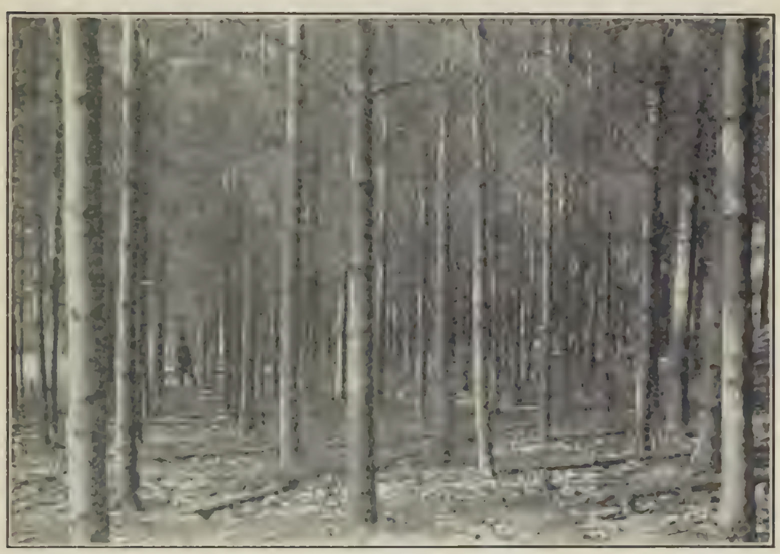


Fig. 63.—Interior view of a 24-year old Norway spruce plantation after thinning and pruning. Many of these trees are large enough to cut for pulpwood, which is worth from $3 to $5, or more, per cord on the stump. This type of forest frequently produces from 10 to 20 cords per acre in about 30 to 50 years, depending upon site and soil conditions.

While no hard and fast rule may be laid down concerning thinnings in actual practice, nevertheless, certain methods have been found to yield the best results. During the first part of the rotation, at least, a " C " thinning is necessary, while later, a " D " thinning may be used.

The French system of thinning is considered quite desirable, especially for white pine. According to this method, the trees to form the final crop are selected, and all trees in any way interfering with the selected specimens are removed, regardless of tree class. The remainder of the stand is untouched, except that dead and dying trees are removed. By selecting 150 to 250 stems per acre and favoring them, bigger and better trees are produced and the soil is protected by retaining the intermediate growth.

Another system of thinning, Borggreve's method, which is sometimes used in Europe, is almost opposite in principle to the preceding. According to this plan, the largest trees are cut, and the dead and suppressed trees besides, leaving the co-dominant trees to furnish the final crop. This method has many drawbacks, since large holes are made in the canopy and the trees which are left cannot always recover from earlier suppression; consequently, the growth rate does not show the pronounced increase desired.

In American forestry practice, the " C " grade of thinning, after the French fashion, has the widest use, and will ordinarily give the best results.

Damage Cuttings. It is a decidedly unusual forest that is not visited from time to time by one or more destructive agencies. The ponderosa pine of the West has been hard hit by the bark beetle at various times; the larch saw-fly has inflicted heavy damage upon the tamarack of northern New York and the Lake States, from time to time. Following the visit of any destructive agency, whether insect, fire, fungus disease, or wind, it is only good management to remove the injured material before it is a total loss. In addition, if either insects or fungus disease is the destructive agency, the removal of dead material may assist in checking the ravages. This was clearly proved by the splendid results attending the bark-burning campaign carried on by the government in its warfare on the Black

Hills bark beetle. Such a cutting, of course, is largely for salvage, and the question of keeping the canopy intact cannot be considered. Large holes are often made in the canopy which nothing but underplanting will repair.

Pruning

When the trees in a stand were too widely spaced in youth to have pruned themselves naturally, artificial pruning is sometimes advisable. However, it is an extremely intensive procedure and, for the most part, should be classed as an aesthetic, rather than an economic, measure. If young reproduction is interfered with, a careful pruning may produce excellent results at a trifling cost in comparison with planting.

FIG. 64.—Pruning and thinning a stand of young planted Scotch pine in Pennsylvania. Nearly all young and immature stands require improvement thinnings to provide room for more rapid growth of trees left for the final stand and to eliminate insect and disease infested trees.

Artificial pruning in the United States is largely confined to the removal of dead branches for a distance equal to one log length up the tree. Schenck's plan of cutting off green branches, leaving a stub 6 to 8 inches long, and two or three years later knocking these stubs off with the poll of the axe has some points in its favor. Ordinarily, pruning of green branches is not favorably regarded, since the open wound permits the entrance of fungi, and in addition sawmill operators claim that this pruning causes loose knots in the manufactured lumber.

White pine in pure stands often fails to clean itself properly. Its value as clear lumber is much higher than when knotty. In such circumstances, the expenditure of $2 to $3 per acre in pruning one hundred of the best trees would be a sound investment that would ultimately yield splendid returns.

The regulation pruning tools are used, and for good-sized limbs a long-handled saw will prove most effective. In every case a clean cut, that will soon heal over, should be left.

Pruning in the United States can be done for 3 to 4 cents per tree, where only the lower limbs are taken off. In Germany, where all dead limbs and green branches up to 3 inches in diameter are sometimes removed, pruning formerly cost about 6 cents per stem. The cost per acre is kept down by confining the operation to those trees that will be harvested last; otherwise the cost would be prohibitive.

Girdling

Inferior species in various parts of the country have been eliminated from the stands by girdling. This is the cheapest method of causing their death, preventing undue root and crown competition. It is one of the more advanced forms of technical forest management adopted where methods of this kind may be successfully used.

The most effective girdling has been done in the Northeast, especially at Corbin Park, New Hampshire, where plots were established in 1905, and on the operations of the Finch Pruyn Company at the headwaters of the Hudson River in New York where inferior, unmerchantable, and practically worthless hardwoods, chiefly beech, have been eliminated by girdling on several thousand acres. Westveld of the U. S. Forest Service has reported the following conclusions from extensive girdling experiments conducted in the Northeast.

irdling – cutting thru inner bark &
mbium & stopping circulation of sap.

1. Stands of red spruce that have been liberated by girdling produce pulpwood several times as rapidly as stands not so treated.
2. Wherever a satisfactory softwood understory or reproduction is present, girdling of inferior hardwoods will convert a mixed spruce-hardwood stand into one of nearly pure conifers.
3. Satisfactory returns may be realized on the investment for girdling even where the coniferous pulpwood crop may not be harvested for 40 to 50 years after girdling.

Because damage may result from felling undesirable trees in thinning operations and for reasons of economy, trees are often girdled rather than chopped down. This is especially true of hardwoods more than 6 inches in diameter.

Cypress is sometimes girdled one or more years before felling, both because the seasoning of lumber cut from them is thus facilitated and because the deadened trees will float better when sawed into logs in the water transport to the sawmills.

Economic Considerations

While there is some objection to thinnings and improvement work, as unnecessary and unnatural measures, nevertheless Continental experience has proved that they are well worth while. It is true that the removal of trees from an immature stand causes a certain amount of damage to the remaining trees, but that is trivial in comparison to the retarded growth and misshapen boles that would result were thinnings not made.

In shallow-rooted species, thinnings may be impossible but, by beginning early and cutting judiciously, it is nearly always possible to remove some of the least desirable specimens.

Therefore, the question is not whether thinnings, cleanings, etc., are advisable, but whether the desires and financial status of the owner will warrant such an expenditure, and whether the increased value of the product will pay for the present investment.

The general statement may be made regarding American forestry conditions, that under ordinary circumstances *improvement work should be postponed until the material is at* *least large enough to pay the expenses of removal.* If the circumstances of the owner and market conditions warrant, a slight outlay should be made for the benefit of the future yield.

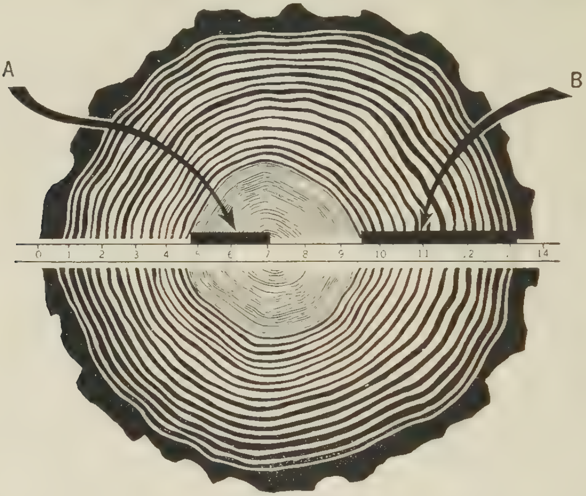


Fig. 65.—How thinning increases the rate of growth. *A* shows very slow growth over a period of 35 years before thinning, during which there was a radial growth of less than 2½″. *B* shows rapid growth for 16 years after thinning, during which period the tree grew in radius over 3″. Thus the tree grew more than twice as fast after thinning operations.

Any system of forest management necessitates a certain amount of sacrifice, even if profits are simply deferred; but to convince thinking men the future returns should be assured.

The cost of improvement work, on the whole, is not excessive and, although thinnings, for instance, may increase the cost of cordwood from 10 to 20% over extensive methods, the investment, on the whole, is worth making.

CHAPTER VIII

TREE PLANTING OR REFORESTATION

General

From the frequently repeated assertion, that " fire protection is 75% of the forestry program," it might be inferred that artificial methods of restocking idle acres are of relatively little importance. The contrary is seen to be true when the full facts concerning our idle land situation are known.

According to the figures cited in recent reports, there are at present 100,000,000 acres of practically denuded land in the United States. To this unproductive area there is being added from 3,000,000 to 4,000,000 acres per year as the result of extensive lumbering operations and forest fires. There are 4,000,000 acres of National Forest land in need of reforesting according to the 1936 annual report of the chief forester. When it is realized that, as a rule, a full generation must elapse before these waste areas will support forests composed of desirable species, the necessity for making this vast domain immediately productive can be readily appreciated. Even where the soil is covered with trees of some economic value, under-planting or stocking the open spots with more desirable species — for example, conifers in the mixed hardwood stands of the East — may increase the ultimate value of the final crop to a marked degree.

The first mention of forest planting of which we have a record was made early in the thirteenth century, when the cities of Nuremberg and Frankfort, Germany, attempted artificial regeneration. These results were more or less experimental, and it was not until the beginning of the eighteenth century that forest planting was practiced on any large scale. Wildlings were used at first, but they gave way to artificially propagated seedlings, and in 1840 the use of transplants became quite general in German forest practice.

In the early history of the forestry movement in the United States, forest planting occupied quite a prominent position; but since the chief reason for most of the planting was to acquire land under the Timber Culture Act, short-lived species which made a quick showing were largely used, with the result that these plantations did not long endure.

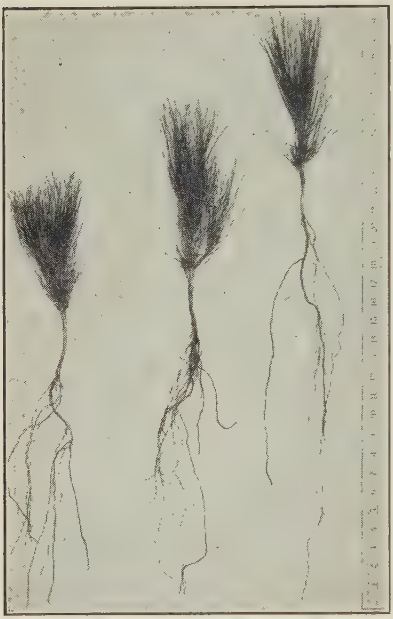


FIG. 66.—Three seedlings of ponderosa pine widely used for reforestation in the Rocky Mountain and Great Plains regions. The seedling on the right is 32″ long. The other two have better developed root systems with branching tendrils. This is a very drought-resistant tree and sends long root systems into the soil to secure the necessary moisture.

From one point of view, extensive reforestation in the United States seems unnecessary, when half-grown timber may be bought in different parts of the country at a price less than the cost of planting. But, in view of the vanishing timber supply and the vast and increasing area of idle land, reforestation on a large scale appears to be the best solution.

The planting of timber trees has great possibilities in the prairie states, where fence posts, building material, etc., are valuable, and where the indirect influence of windbreaks is also of great importance. In regions where large areas of second-quality land are to be found in close proximity to good markets, forest planting promises to yield good results. For instance, there are thousands of acres in the Eastern States which could be planted with forest trees to good advantage. New York for some time has supplied planting stock at cost and has a nursery output at present of approximately 60,000,000 seedlings per annum. Massachusetts has recently initiated a plan for the purchase and immediate planting of 100,000 acres of idle land. In both these states, the forest industries and population as a whole will profit from the cheaper "home-grown" raw material.

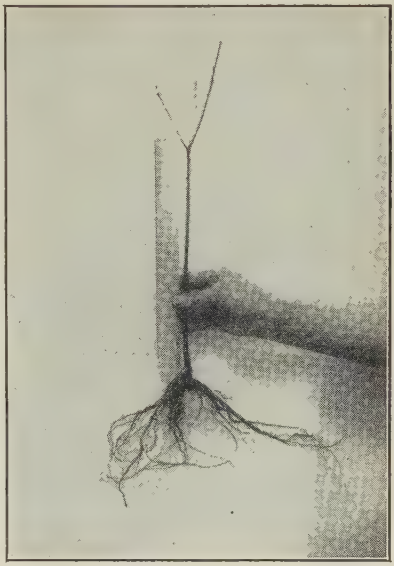


Fig. 67.—Two-year old red oak planted as acorn in cultivated strip. Comparison with foot rule shows height growth. Photo by S. O. Heiberg.

The advantages of reforestation can be briefly expressed as follows:

1. As an economic measure, forest trees should be planted only on land too poor for agricultural purposes. This will bring land into use that would otherwise be idle.

2. Planting will tend to raise the quality of timber that is produced. Our forest lands have suffered in the past from neglect, and have produced weeds rather than desirable timber trees. With more intensive management, much better material will be produced.

3. The experience of European foresters indicates that, with the rise in stumpage that will inevitably occur, forest planting must yield a higher return than we anticipate now; and, aside from making idle land yield, forest planting is really a good financial investment.

There are certain drawbacks, however, to the situation. Fire, of course, is likely to wipe out a plantation in a short time; fungus diseases, drought, etc., may also render such an investment precarious. Finally, excessive taxation might seriously disturb the estimated returns. The latter objection, however, can be eliminated by enlightened legislation, which the different states are now considering. None of the drawbacks is serious enough to deter any owner of idle land.

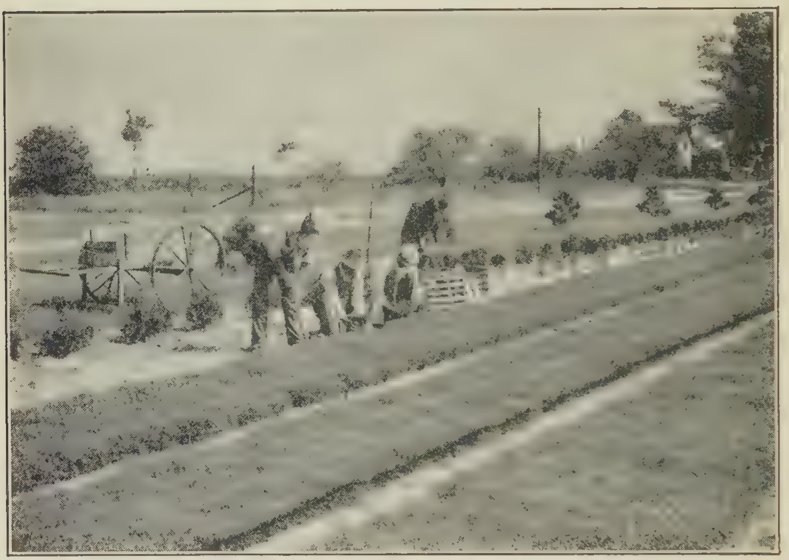


FIG. 68.—Workmen lifting and packing Norway pine seedlings at the Beal Nursery, Huron National Forest, Michigan. This operation is done in the spring, which is the best time for planting in the northern zones.

Status of Forest Planting

Abroad. Practically all the foreign nations are planting at the present time. France, in controlling her mountain torrents, has restored more than a million and a half acres to forest cover. Switzerland, up to the beginning of the twentieth century, had reforested over 16,000 acres. Before the war, Russia, with her vast areas of virgin forests, was planting extensively, and in Germany the Prussian foresters alone were planting on an average of 50,000 acres a year.

In the United States. Planting was started in the United States in 1843 and is now being extended as fast as material and funds will permit. At the present time some experiments

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are being carried on along lines of direct seeding. Large nurseries are operated by the Forest Service; and the use of seedlings and transplants is on the increase. Besides the actual planting operations, the germination of seeds and the heredity of the various species have been tested, and the success of various methods of direct seeding has been proved.

In 1936, men of the Civilian Conservation Corps planted more than one billion trees, largely on National Forest and Park lands, State Forests and Parks, also the Tennessee Valley Authority, projects of the Soil Conservation Service, Resettlement Administration and other projects.

Of all the states engaged in reforestation, New York takes the lead, closely followed by Pennsylvania. New York at the present time has four large nurseries with an output of about 60,000,000 trees per annum. In Massachusetts, in addition to reforestation of state land, the unique system of planting land loaned to the state for a period of years has been put into effect. The original owner can reacquire this land by paying the cost of operation within ten years. Various railroads, water companies, and paper companies are practicing reforestation on an economic basis, since they realize that any corporation permanent in its organization and owning large areas of land can practice forestry effectively and profitably and, at the same time, provide for a future supply of raw material.

Private planting has always been practiced in the United States by individuals, with great success, and large plantations up to 300 or 400 acres are often established by landowners interested in forestry. Individual enterprise for forestry planting is likely to be checked by the thought of the length of time to elapse before harvesting the crop, but with a corporation, or state, this argument has no weight. However, in certain sections of the country, individuals are planting forests to raise material on a short rotation that will beautify and enhance the value of their land, and at the same time yield a good income on the investment.

The U. S. Forest Service has established large nurseries in

Michigan, Louisiana, Montana, Minnesota, Mississippi, Wisconsin, Missouri, California, Colorado, and Washington to produce many millions of seedlings and transplants annually. These are planted largely by the men of the Civilian Conservation Corps. The Soil Conservation Service and the Tennessee Valley Authority have also established large nurseries. Federal nurseries have a production capacity of over 400,000,000 trees. The Forest Service reforested 140,000 acres of National Forest in 1936.

Seed Collection and Storage

The seed is the resting stage of plant development, and is produced after several seasons of favorable climatic conditions. Some seed may be produced every year, but the abundant production occurs at intervals. Most seeds take but one year to mature, but black oaks and the pines take two years and the junipers may take one, two, or three.

Most seeds ripen in the fall, but willows, poplars, elms, and soft maples ripen in the early spring and must be gathered at once. In nature, the seeds are disseminated in a variety of ways. Some are provided with wings to aid their transportation by the air, others are contained in a fleck of down, which enables them to be carried long distances. Some are berry-like in form and depend on the birds for distribution; still others depend on gravity.

The time to gather seed depends on the time the seed or the fruit matures. It should be gathered as soon as it is ripe, but before nature starts to scatter it. If seeds are wind-sown, they should preferably be picked from the tree; but sometimes such seed as elm, maple, and ash may be picked from the ground in large quantities. With conifers the cones are either pulled off with rakes, or, if a lumbering operation is available, the cones may be picked from the fallen trees.

Trees in middle life produce the best seed; also those that have had good light in youth.

Cost of Collection. The cost of seed collection varies greatly with the species, the season, and the methods used.

White pine cones during good seasons may be gathered on a logging or lumbering job at a cost of 50 cents a bushel for the cones. From this figure, the price may range up to $2.50 a pound for collecting cones of species which bear but few cones each season. The locality in which seed are gathered has considerable bearing on the future seedlings, as seedlings grown from seed collected in a southern climate are likely to prove very weak if set out in a colder region. Black walnuts gathered in Missouri, for instance, were killed by spring frosts in Minnesota, when those grown from local seed came through the season unscathed.

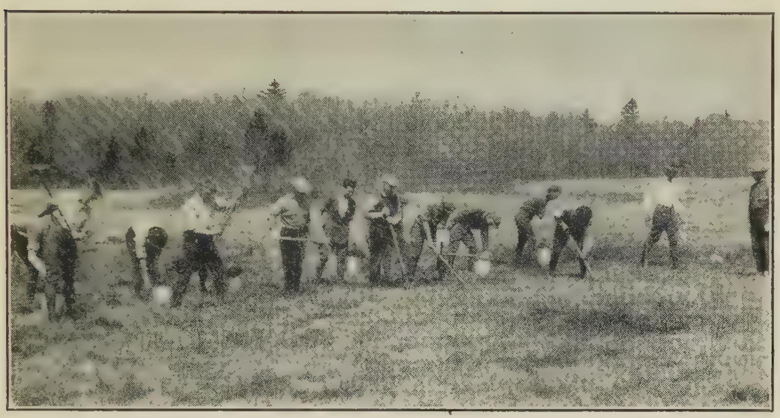

Fig. 69.—Fourteen men working in two-man crews with foreman directing the planting of trees on a typical abandoned farm in New York. One man cuts away the sod and makes a hole with the mattock and the other, with the little trees, inserts the tree and firms the soil about it. Two men can readily plant 1000 trees per day spaced 6′ by 6′ apart under favorable planting conditions, such as represented in this picture.

Storage of Seed. While nature plants seed almost as soon as they are mature, it is a better plan to keep the seed or fruit over the winter and plant it when the weather conditions are more advantageous. The seed of species like elm, maple, poplar, and willow are hard to keep, however, and ordinarily must be planted at once. Seed that usually keep over winter must be stored dry, and those that have a tendency to dry out must be enclosed in air-tight receptacles. Most fleshy fruits require stratification, which consists of laying alternate layers of fruit or seed and moist sand in a box and burying it on a hillside, where drainage is good. Small seed like ash, for instance, which tends to " lie over " unless forced, could be stored between layers of cheese-cloth covered with sand. When planted the ash will ordinarily germinate immediately. Commercial houses rarely practice stratification, because they have storehouses where moisture conditions are kept uniform. Nuts and acorns may be kept in bins; small seed can be kept to advantage in large glass bottles or carboys. Whatever form of storage is used, care should be taken that rodents cannot reach the seed.

Seed Extraction. At the present time, the extraction of seed from cones is carried on with considerable skill by seed companies in the United States, and the Federal Forest Service has recently commenced to gather and extract coniferous seed on a considerable scale. In the National Forests, cones are often gathered in inaccessible places and are carried to an extracting station in large bags of canvas cloth. They are spread out on canvas in thin layers and exposed to the full sunlight to hasten drying. From time to time, the cones are stirred, and they are covered during the damp weather and at night. As the cone scales open under the drying influence of the sun, the seed falls out upon the canvas sheets. A large amount of the seed falls out naturally in this way, but, as a final resort, the open cones are put in a churn, made from a rectangular box with slatted sides, and turned until all the seed are threshed out. The seed is then cleaned by crushing the wings against a sieve, and, after the chaff has been removed by winnowing, it is packed in small bags for transportation.

The method adopted in commercial seed-extracting establishments is the same as the above in principle. The cones of such plants, however, are ordinarily allowed to dry outside for a few days before they are exposed to artificial heat. In the drying room the temperature of 120° F. will cause the cones to open in a few hours. Then it is merely a question of threshing the seed and removing the wings and chaff.

German seed-extracting establishments lay great stress upon the fact that the seed must not be injured during the process, because, if the seed coats are cracked in any way, fungus spores can find entrance, or the cotyledon will be acted upon first in germination, which will make the seedling practically useless for planting. Although extracted seed can be kept over until the next season with little loss, cones cannot be so retained, as the seed will rapidly deteriorate owing to the moisture present within the cone.

Commercial seed houses ordinarily test their seed from time to time, and the results are carefully recorded for each batch of cones. This serves as a check on the quality of the cones and on the technique of the extraction. Seeds are tested by being placed on plots of sand or moist blotting paper and exposed to uniform heat and moisture conditions.

Direct Seeding

There are two general methods of planting seed directly in the field: broadcast and partial seeding.

In *broadcast* seeding all parts of the area receive the same amount of seed; for this method to be successful, the soil must not only be good, but it must also have the faculty of retaining moisture in the superficial layers long enough to induce germination. If the downward growth of the root can keep ahead of the drying out of the soil, broadcast seeding will ordinarily result successfully. Some preparation of the soil is necessary, as a rule, since it is practically useless to sow seed broadcast on a thick sod or on ground densely covered with weeds. In open woods with loose soil, broadcast seeding may be advantageous if seed can be cheaply procured.

The Federal Government has had some success in the Black Hills with broadcast seeding on burned-over lands; but there it has been found that, aside from conditions of soil and season, the presence of rodents has a very important bearing upon the outcome. From the experience gained in that region, it is believed that squirrels, field mice, etc., must be poisoned before broadcast seeding is attempted; otherwise it will prove a failure.

To get a thick stand of seedlings in eight or ten years, a large amount of seed is required; and, unless very cheap seed are available, planting is apt to be more economical and certain than broadcast seeding. In broadcast seeding experiments conducted in North Carolina, the following amounts of seed per acre were found necessary: ash 40 pounds, maple 40 pounds, white pine 12 pounds, spruce and larch 10 pounds, yellow pine 8 pounds. Even at a low cost for seed, it will be seen that broadcast seeding is doubtful economy, and, as a rule, there will be a closer and more uniform stand if seedlings are planted.

Partial seeding, in which the seed is not uniformly scattered, is, on the whole, much better than broadcast seeding because of the decreased cost. Partial seeding has a number of advantages over the preceding method. Less seed are used and, therefore, only the best places are selected for seeding and the remainder left untouched. This means better covering of the seed, with greater chances of success. Partial seeding may be practiced either as strip seeding or spot seeding. In the strip method, the seed are sown on strips of cultivated or broken soil, with untouched rows alternating. If weeds or sod are present, the strip of cultivated soil varies in width depending upon the intensiveness of the operation and the character of the ground. In ordinary circumstances, the cultivated strip will be one-eighth of the untouched portion.

This method has been used somewhat in the past and several cases are on record in New England where pine cones were planted in furrows, giving a decidedly dense stand.

Seeding in spots is the most common method of direct seeding employed. The seed spots vary in size from 4 inches square to 30 square feet, depending on the size of the seed sown, on the condition of the soil, and on the kind of ground cover. Direct seeding of this kind can be used in places where a plow cannot run, and where the woods are open only in spots. The ordinary practice is to scratch the surface of the soil for about 3 inches square, and, if the spots are spaced 6 feet apart, there will be 1210 seed spots to the acre. When the sowing is on heavy sod, it is customary to remove the sod and, after working up the soil, place the seed on the loose dirt, and cover it lightly. Field planting by means of the spot method in Massachusetts and New Hampshire has given fair results, although the late spring frosts are likely to heave the young seedlings to a marked degree. Under the most favorable conditions, seed-spot methods may work to advantage; but outside the open woods the seed are protected from frost with difficulty.

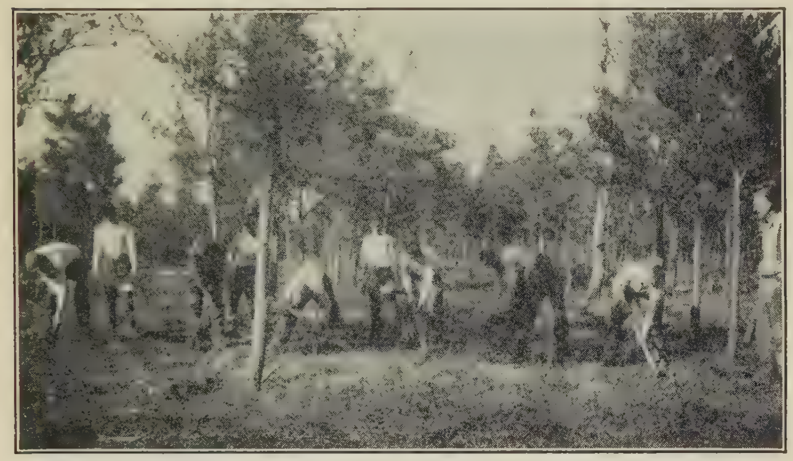

FIG. 70.—Crew of Civilian Conservation Corps planting pine seedlings in an open stand in need of reforestation in Michigan.

With tap-rooted hardwoods, however, the planting of the seed directly in the fields is desirable, and results are likely to be better than when the seedlings are used. In this method also, rodents or birds are likely to do considerable damage, so that the acorns and nuts should be treated with a heavy coat of red lead or other poisonous preparations before planting.

Results and Costs. The stand of seedlings obtained by direct seeding may vary widely, depending on soil, season, presence or absence of rodents, and method of distributing seed. As stated above, unless seed are extremely cheap, or the use of seedlings made impossible by the size or the accessibility of the area to be planted, direct seeding is far more costly, as measured by number of seedlings secured per acre, and on the whole less satisfactory than the planting of stock seedlings.

Nursery Practice

By all odds, the most widely used method of reforestation is that of planting nursery seedlings or transplants on the area where forest cover is desired. This method, apparently more expensive, has proved, for the most part, to be the most economical in the end.

Seed and Transplant Beds. No point in nursery practice is more important than the selection of a desirable site for the forest nursery. Not only are good soil and plenty of water necessary, but drainage, slope, and accessibility should also be kept in mind.

The soil should be a mellow loam, free from stones, well drained, and free from weed seeds. The ground should be cultivated a year previous in order to free the soil from any weeds. Any attempt to raise seedlings on ground which was in sod the year before is likely to result in a heavy loss, owing to the action of the larvae of the May beetle on the roots of the young seedlings.

With the site of the nursery selected, the size will depend on the scope of the planting operation; one-half acre will produce 145,000 three-year transplants annually.

If land is available, it is wise to have the nursery large enough to permit rotation of crops, so that seedlings, grass, and transplant beds may alternate on the same area. The beds should be worked up in the spring as soon as the frost is out of the ground and laid out running east and west, preferably, in order that proper sunlight may be available. Four feet is the standard width for beds, and the length may vary according to the plot. Four by twelve feet is taken as a standard, although modern nurseries have beds up to 100 feet long. Heavy fertilization is the custom, and two barrels of rotted leaves and the same amount of well-rotted manure to 50 square feet of ground are the ordinary application. The ground is well mixed with the manure and the mixture finely pulverized, before the seed is sown.

The beds are ordinarily raised slightly above the ground in order to insure good drainage, and the surface of the bed should be free from pockets, so that water will not collect in the spring. Aside from raising the beds 3 or 4 inches above the level of the path, it is customary to crown the surface of the bed slightly in order to secure better drainage.

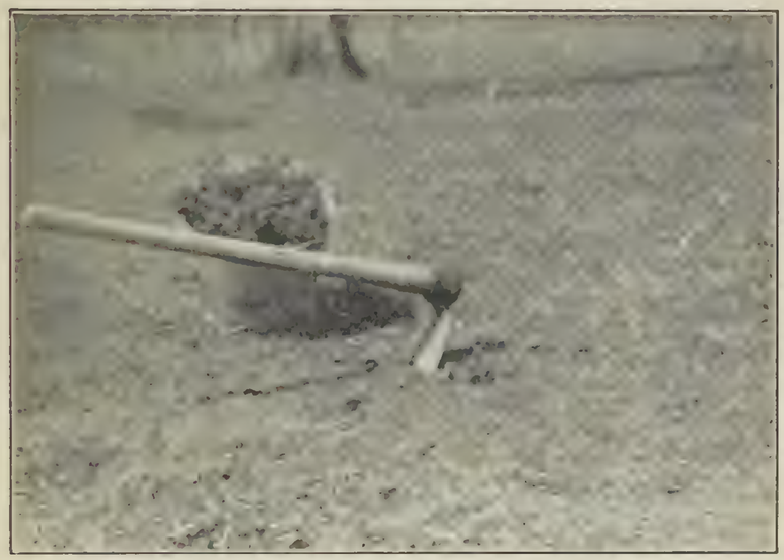

Fig. 71.—One of the principal planting tools is the mattock. Little trees ready for planting are shown in the pail with the roots kept moist in mud or other matter for retaining moisture about the root tendrils. One man opens the hole with a mattock, the other inserts the little tree as shown in the left foreground. Two men can readily plant a thousand trees per day under favorable growing conditions.

Side braces or frames are largely a matter of convenience. The most intensive nursery practice calls for well-built frames with netting surrounding each bed, whereas many commercial nurserymen merely sink a 3-inch board about 1 inch into the ground. In small nurseries, wire screens made of ¾-inch mesh are used to cover the beds, so that the birds will not tear the bed to pieces by picking at the husks of the seeds.

Screens of laths, placed so as to make half shade, are used to prevent too much light. These are best used in lengths of 6 feet, as one man can handle this size. High screens, made of laths or brush, are used sometimes; but, with high shade, advantage cannot be taken of any dull day to harden the seedlings, and, on the whole, low shade maintained by the use of lath screens fitting directly over the frame is considered more desirable.

After the beds and screens have been prepared, the sowing can be started. The amount of seed used for one bed, 4 by 12 feet, is approximately as follows:

Species	Ounces per 4′ × 12′ bed	Number of seed per pound	Average germination percentage
White pine	10	30,000	60–70
Red pine	6	80,000	70–80
Scotch pine	8	70,000	60–80
Pitch pine	10	50,000	65–85
Jack pine	6	90,000	60–80
Norway spruce	8	65,000	60–70
Red spruce	6	120,000	65–80
White spruce	8	100,000	60–70
European larch	16	75,000	50–60
Balsam	12	50,000	35–60
Arborvitæ	6	175,000	60–70
Hemlock	8	80,000	35–65

The seed bed is generally moistened thoroughly before sowing is started, and the seed are then lightly covered by passing loam through a fine sieve. Then the surface of the bed is firmed by pressing with a clean hoe or plank.

One of the most important points to be observed in nursery planting is the securing of absolutely sterile dirt to cover the seed. " Damping off," a fungus disease attacking the young seedling during the first few weeks of its existence, is especially likely to be present when the loam of garden soil has been used. Consequently, sterile soil secured from 3 to 4 feet below the surface should be used in covering the seed. The beds are then covered with the screens, and burlap or leaves may be placed over the surface of the bed to keep the ground dark and moist until germination is completed.

In ordinary circumstances germination will take place in fourteen to sixteen days for the conifers. Care should be taken not to delay the removal of the burlap or leaf covering; otherwise the young seedlings may be entirely smothered. The lath shade is kept on continuously during the first summer, except during cloudy days, when it may be removed to give more light to the seedlings and to prevent the danger of " damping." Drought is also to be guarded against during the first season, and during any prolonged period of dry weather the natural moisture should be supplemented by careful sprinkling. Weeding is particularly heavy the first season, especially if the land was not well cultivated previously. Weeding and attention during the first year costs from 15 cents to 20 cents a thousand.

At the end of the first year, the cost of seedlings raised on a scale of two to three million will be around 68 cents per thousand in the bed; but overhead charges on a small nursery would raise these figures. Weeding is ordinarily discontinued about September first, and whatever grass or weeds grow afterward are allowed to remain, in order to protect the roots of the young seedlings during the winter. The lath screen is also removed, late in the fall, to harden the seedling, and, as winter sets in, a mulch of weeds should be thrown on top of the seed bed or a strip of burlap placed on top of the first fall of snow to prevent rapid thawing out during the following spring. If the operation has been carefully carried out, there should be approximately 200 seedlings per square foot, or 9,000 to 10,000 seedlings for the unit bed.

In the spring of the second season, the bed can be moistened and seedlings can be picked out, leaving from 75 to 100 to each square foot. Those that remain will have additional room for their development and those removed can be put in the transplant row.

At the beginning of the second season, the bed should be uncovered as soon as the frost is out of the ground; and careful watch should be kept to avoid heating by retaining the cover too long. Attention during the second season is much lighter, consisting of a little weeding and an occasional watering. The tops, by this time, will form a dense mat which will keep the ground moist and will crowd out weeds. At the end of the second season no mulch is necessary, as the roots are now deep enough to prevent heaving.

Ordinarily, the seedlings do not remain longer than two years in the seed bed; at the beginning of the third season, the plants are generally removed and placed in transplant rows for better development of their root system. The cost, at the end of the second season, is approximately $2.60 per thousand in the bed. If shipping is contemplated, 60 to 70 cents per thousand for digging and packing should be added to this cost.

Planting material should not be too toppy, as the main advantage in artificially grown seedlings is the character of the root system rather than the size of the tops. Too large material is a drawback, being bulky and not able to stand the shock of removal; consequently, a year or two in the transplant beds is very beneficial. These beds consist of rows 12 to 15 inches apart with the seedlings placed from 1½ to 3 inches apart in the row. This spacing will permit the planting of from 150,000 to 300,000 seedlings per acre, and by the use of long beds, weeding with machines can be practiced, which will greatly reduce the cost. In some parts of the country, the seedlings are allowed to remain but one year in the seed bed and then two years in the transplant bed. This " 1-2 " seedling, so-called, is quite desirable for certain situations. The more common way is to permit the seedling to remain two years in the seed bed and either one or two years in the transplant bed, making 2-1 or 2-2 transplants. The transplanting in rows was first done by hand, but the Yale transplanting board, invented by Prof. Toumey of the Yale Forest School, has simplified this operation, increased the speed remarkably, and greatly reduced the cost.

Field Planting*

Reforestation of open country is by far the most common form of forest planting, although underplanting is being practiced to some extent. The idea of establishing forest covers on watersheds, and providing for a future supply of timber, are the chief economic reasons for planting, although the aesthetic value of forests should not be overlooked. Shelterbelts, however, are extremely important in certain parts of the country. Investigators claim that, in the states of Kansas and Nebraska, where enormous losses are suffered by the farmers owing to the hot winds which sweep up from the south, 20% of the area could be planted to shelterbelts running east and west, and the remaining 80% of the land would produce as much in agricultural crops as the total does now. In addition, the comfort of the inhabitants would be vastly increased, and there would be considerable incidental revenue derived from the timber production of these forest-covered strips.

Choice of Stock. The following points to a large degree control the kind of planting stock used:

1. *Soil and Moisture.* The kind of soil and amount of moisture practically control the choice of species. Hardwoods must have fairly rich and moist situations as a rule. Among the conifers, white pine may be used on medium sandy loam, but Norway, Scotch, and ponderosa pine, for example, may be used on the lightest and sandiest soil.

2. *Climate.* The bearing of climate is very important also, for it is almost useless to plant a species outside its geographic range, or in a region of decidedly different climate. According

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*Since 1933, enormous advances have been made in planting by the Civilian Conservation Corps. In 1936 the U. S. Forest Service reforested 140,000 acres. Most of this was done on non-productive lands in the Lake States and South. Over 71,000 acres were planted in Michigan and 24,000 acres in Wisconsin.

to Mayr, zones of like climate are to be found in different parts of the world, so that Japanese species may be planted successfully for ornamental purposes in the eastern part of the United States. On the whole, it is not practicable to plant western species in the East, or northern species in the South.

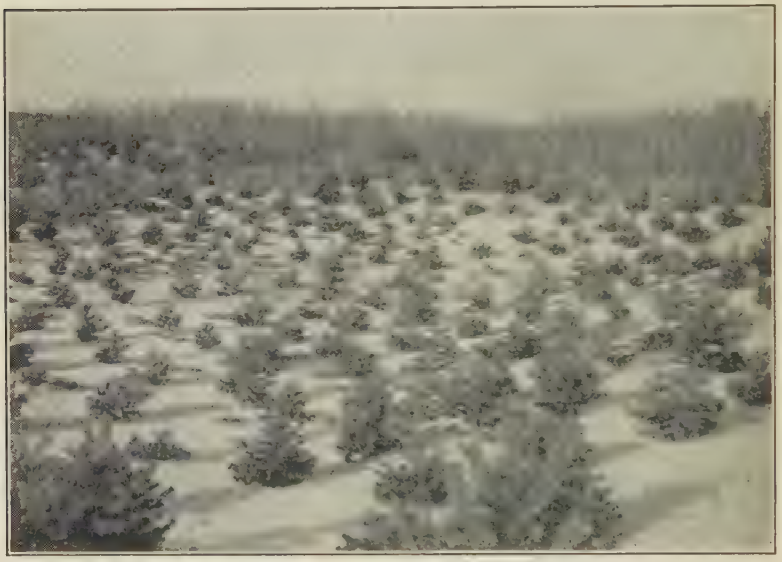

FIG. 72.—A successful coniferous plantation on blow sand. The fixation of blowing and eroding soils by planting trees is of great importance in many parts of the country.

3. *The Desire of the Owner.* The ultimate plan of the owner should be thoroughly understood, and a sharp line should always be drawn between aesthetic and economic planting.

4. *Density of Shade and Amount of Ground Covered.* Only tolerant species can be used where there is a dense growth of weeds.

5. *Market Demands, Present and Future.* If a plantation is to be made from an economic standpoint, the future as well as the present market possibilities should be taken into consideration. In Massachusetts, the white pine is now and probably always will be the most salable species, owing to the

box-board industry. In western New York State and in the Middle West, fast growing, durable species, like red oak, or catalpa, can be used to produce vineyard stakes, fence posts, etc.

6. *Resistance to Attacks.* Species should be chosen with special reference to their freedom from the diseases which may be prevalent in the region. Oaks are particularly subject to attack by the gypsy and the brown-tailed moths in Massachusetts. The chestnut-bark disease may make the planting of chestnut very hazardous throughout its whole range, and white pine, in certain portions of the East, suffers severely from the ravages of the white-pine weevil. As a general recommendation, it is not safe to decide on the species to be used without study of the local conditions. The soil and moisture conditions should be noted on the ground, and a careful study of the market situations and the desire of the owner made before choosing species.

Age. Nursery stock is classified as seedlings, either one, two, or three years old, generally sold on a basis of size, or transplants which have been put in beds one or more times to improve the root system. Complete specifications of a transplant cover the number of years in the seed bed, the number of years in the transplant bed, number of times transplanted, and the size. For instance, a 2–2 transplant, once transplanted, 14 inches tall, would be the nurseryman's method of describing stock. The price, of course, is increased by the extra handling, and, as a rule, a seedling the same size as a transplant is worth about half as much. As a general statement, it may be said that the smaller the planting material used, the more successful will be the operation, since the younger stock can stand the shock of field planting much better, can be handled much more easily, and costs considerably less.

Transplants, of course, can stand more drought and shade, and must be used where these conditions are met. Most broadleaf species are put out as one-year stock, but conifers will average from two to four years of age when finally planted. Scotch pine, however, is sometimes planted at one year; but one-year coniferous stock is rarely planted successfully in the United States.

Technique of Planting. On the arrival of the material on the planting site, the hampers or baskets containing the seedlings are opened, and the bundles, which are usually packed in moist sphagnum moss, are taken out and loosened. The roots are dipped in a puddle of mud; and then the loose bundle is laid on the side of a sloping trench, the earth thrown upon the roots and gently firmed. This is done to prevent the fine root hairs from being dried out. Plants can be kept for three weeks if necessary, provided the situation is shady. The tools needed in a planting operation are mattocks or spades and water-tight pails. The best results are obtained by keeping a layer of soft mud, 2 to 3 inches thick, in the bottom of the pail in which the roots are kept moist. The planting crew consists of two men as a unit, one using the mattock, the other inserting the tree in the hole made by the mattock man. Ordinarily, these men can keep fairly accurate lines, but, if especially straight lines are desired, it may be wise to stake the field off or use lines stretched across the area.

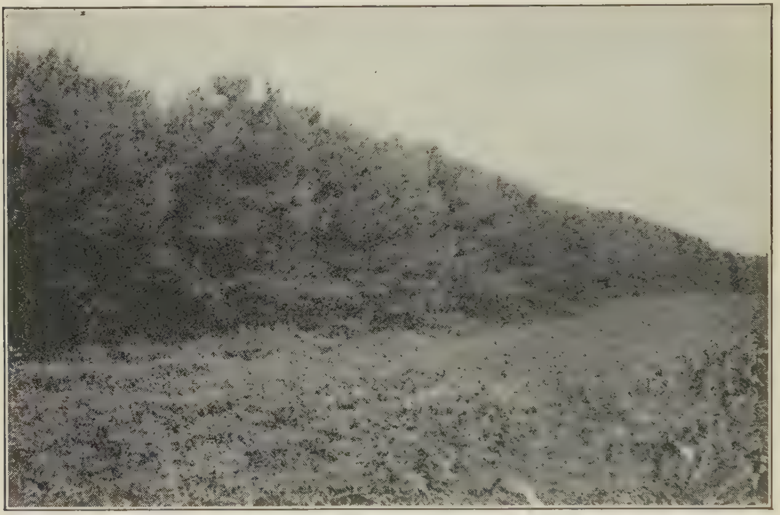

Fig. 73.—A Scotch pine windbreak in Minnehaha county, South Dakota.

The ordinary planting space is 6 feet apart each way, for economic planting, which requires 1210 trees to the acre. A planting crew can cover from $\frac{2}{3}$ to $1\frac{1}{4}$ acres a day, depending on the size of the plants and the character of the soil.

In southern California, one-man planting crews insert the trees in cups in the planting site. This is done to give them a better start and enable them to live through the long dry seasons.

Shelterbelts. In certain parts of the West, where hot south winds are frequent, the use of windbreaks is strongly urged. Aside from greatly increasing the comfort of the owner, it has been proved that the beneficial effects of windbreaks upon the growing crops are most marked, and by correct placement they will insure the proper distribution of snow and prevent disastrous piling. The force of the winds can be gently checked by planting windbreaks, running east and west, at a distance of $\frac{1}{4}$ mile, or less, apart. The gardens or orchards in the lee of the breaks will be considerably benefited, the comfort of the family will be greatly increased, and the incidental returns in the form of fuel, fencing, etc., will more than repay the cost. The species giving best results for windbreak planting should be quick growing, hardy, and able to form a dense break. As it is extremely difficult to find one tree that possesses all of these qualities, mixtures are often employed.

The poplars, either Carolina or Norway, the box elder, and the silver maple are fast-growing trees; when planted close, they serve well for a few years, on account of their rapid growth. To achieve the best results, they should be reinforced by some hardier tree, like the white elm, Russian wild olive, green ash, or white willow. The Russian olive will grow remarkably well in poor alkaline soils, but it should be replaced by some of the others in better soils.

Evergreens, of course, make the best windbreaks, but their growth at first is decidedly slow, and a nurse tree is often necessary. The Norway spruce, white pine, white cedar, the ponderosa, and jack pines are the most favorable species for this use, although the spruce requires rather moist soil as a rule.*

The planting distance will range from 4 feet to 8 feet, depending on the growth rate and the branching habit of the tree. Rather close planting is desirable, as the effect is felt at once, and, as soon as crowding is noticed, alternate trees may be cut out. The width of the windbreak is also of importance. Trees in a belt, as in the forest, can protect the ground and assist each other far better than two or three rows of trees. The breaks rarely exceed 2 rods in width, as the snow is likely to pile in and break down the trees. In some cases, two narrow belts of trees may be planted and a small garden planted between them.

Windbreak planting differs from regular forest planting, in that cultivation during the first few years is practically indispensable and, under certain conditions, mulching is quite advantageous. After rapid growth has started and the ground is well shaded, the trees can take care of themselves.

Planting Under Cover. Throughout what might be termed the entire sprout hardwood region, countless woodlots may be found which have been abused and neglected for many years. The desirable species have been removed for lumber, and the ground left practically at the mercy of the forest weeds. Fires have been permitted to run without hindrance, and cattle have been allowed to graze at will, destroying all chances of natural regeneration. As a consequence, we find thousands of acres where the mature trees are going to pieces, and such reproduction as is present is confined to undesirable species. In such cases, planting under cover is an admirable solution of the problem of building up the woodlot. Conifers are favored, for the most part, because the forests described are largely composed of sprouting hardwoods, and a mixed forest is a desirable goal at which to aim. However, hardwoods of rapid growth and high technical value, like ash, basswood, red oak, and tulip poplar, may be inserted to advantage, but, for the most part, spruce and pine as three- or four-year-old transplants are the most desirable stock to use.

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*Trees which showed the best growth and survived the serious droughts of 1935 and 1936 to best advantage were cottonwood, green ash, Chinese elm, red cedar, and ponderosa pine.

The planting operation is practically the same as in open-field planting, and the make-up of the crew the same; only, instead of lining up on a stake or landmark, the crew should endeavor to pick out likely spots in the stand. A good place to insert the seedlings is beneath a hole in the canopy, or where there is a moist bit of soil, or where there is any open space on the forest floor. Tolerant species like spruce must be used if the canopy is comparatively dense, but the transplants can be used on lighter soil, provided there is sufficient light coming through the cover. Such an operation permits the owner to thin out his woodlot later on, and allows a choice between hardwoods and softwoods with the idea that a mixed forest can be obtained. Needless to say, after an operation of this sort, the woodlot can no longer be used for grazing.

Spacing and Costs. The ordinary spacing for open planting is 6 feet by 6 feet, which means 1210 trees to the acre. Where trees are to be planted for a short rotation, as willow for basket withes, black locust or catalpa for fence posts, or poplar for excelsior, closer spacing may be made. In Germany, where planting material is cheap and land is valuable, the foresters plant intensively, sometimes using as high as 5000 seedlings per acre. The following figures will give an idea of the number of trees per acre at the different spaces:

Spacing	Number of trees per acre	Spacing	Number of trees per acre
4×4	2722	7×7	888
4×5	2178	8×8	680
5×5	1742	9×9	542
5×6	1452	10×10	435
6×6	1210	....	....

In underplanting, the number of trees to be used depends largely on the condition of the forest canopy and the desire of the owner. When the canopy is comparatively dense, with but few holes in it, it is useless to plant more than 100 to 200 per acre, unless a thinning is made previously. If, however, the stand is quite open through heavy thinnings or repeated fires, 500 to 600 seedlings may be put in to advantage. In underplanting, either in the average woodlot or in young reproduction, it is possible to take advantage of the sprouts and seedlings as side shade and to place the transplants 5 to 6 feet from an oak or maple sprout, and thus reduce the amount of planting material without impairing the result.

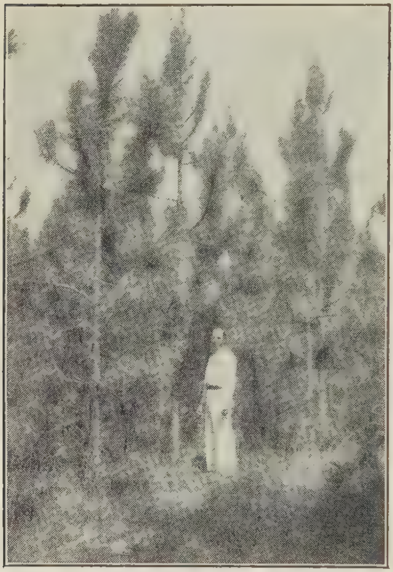

Fig. 74.—Seven-year old planted long leaf pine on private property in Sumter County, South Carolina. Many of these trees are 20′ or more in height. Seedling trees of one season's growth are generally used in reforestation work. Photograph by S. O. Heiberg.

The cost of a planting operation varies widely with the density of planting, the size of material used, and the character of the soil. If large stock is used, the price to make an immediate showing may be prohibitive to the average owner.

By using the smallest planting material possible and allowing for no preparation of the soil, the average cost per acre for open planting, 6 feet apart, ranges from $12 to $15 an acre. For underplanting, where stockier transplants must be used to withstand shade and root competition, the cost of planting material is correspondingly higher; but the smaller number of seedlings used reduces the price. Where transplants can be obtained at a cost not exceeding $6 per thousand, a rough estimate of 1½ cents per tree in the ground is safe; that is, underplanting with 400 trees per acre will cost approximately $6 to $7.

Yields. Reforestation is being urged by foresters chiefly as an economic proposition, although, from an aesthetic point of view, planting has its advantages. Unless it can be definitely proved, however, that the money invested will yield a fair return, forest planting had better be abandoned, or else charged up to landscape improvement. While American forest practice is not old enough to possess the wealth of experience which is available in Germany and France, data are, nevertheless, at hand to prove conclusively that plantations can yield a fair financial return on the capital invested. Forests, however, are a long-time investment and with fair fire protection are quite stable, so that the required interest rate should not be put too high. For estate owners having idle land, or paper concerns desiring continuous supplies of pulpwood, etc., reforestation is a highly desirable investment, and one worth the attention of shrewd financiers. Already, railroads and paper companies in the East have begun extensive reforestation to provide them with future supplies of ties and pulpwood. Water companies, whose drainage areas cannot be grazed or fertilized, for fear of contaminating the supply, are finding forestry an ideal solution of their land problem. Practically

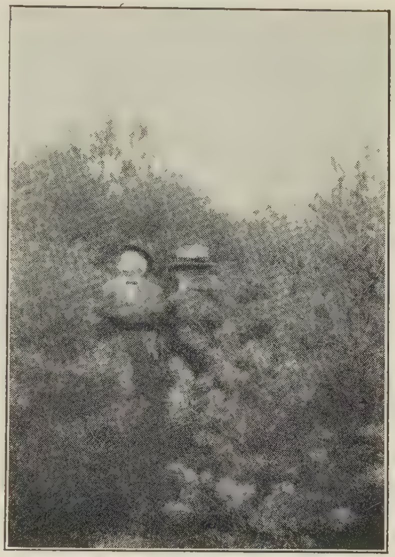

FIG. 75.—Ten-year old white pine plantation on the Luther Forest Preserve near Saratoga Springs, New York. Mr. T. C. Luther is shown on the left. He has planted several million trees on his 7000-acre preserve. His leadership has been of great value in encouraging others to plant trees.

any corporation owning land and with an assured continuous existence can plant trees for future timber supply with profit.

As intimated above, on account of the stability of a forest plantation as an investment, and because of its duration, by which frequent reinvestments are avoided, forests should rank as bonds. Therefore, a comparatively low rate, say 3% to 3½% is all that should be expected. However, investigations have shown that, if a plantation of white pine can be established at a cost of not more than $14 to $18 per acre for land and planting costs, 5% compound interest return on the investment is practically assured, barring any heavy loss or intermediate expense like fungus or insect control. This yield, moreover, is based on present stumpage value, and the certain rise in the price of timber products will cause a remarkable appreciation in this rate. The following table shows what may be expected from a stand of white pine planted on cheap land at an average cost.

The final column in the table shows the net profit over and above the 5% rate. For instance, at fifty years, based on present stumpage values, such a plantation would yield $214.10 more than a 5% investment.

Financial Rotation of White Pine[1]

Money valued at 5%; value of land, $4 per acre; cost of planting, $10 per acre.

Age of stand (years)	Gross returns (stumpage value)	Expenses and interest									Gross profit	Net profit over 5% on investment
		Taxes					Cost of producing					
		On timber			On land							
		Annual for five-year periods	Amount paid in taxes	With accrued interest	Amount paid	With accrued interest	Interest on value of land	Cost of planting and accrued interest	Total investment without interest	Total investment and interest at 5%		
25	$40.50	$0.540	....	....	$1.50	$2.50	$9.54	$33.86	$11.50	$45.90	$29.00	—$5.40
30	75.00	1.000	$2.70	$3.13	1.80	3.48	13.30	43.22	14.50	63.13	60.50	11.87
35	195.20	1.269	7.70	9.80	2.10	4.73	18.06	55.16	19.80	87.75	175.40	107.45
40	262.40	3.498	14.04	19.85	2.40	6.54	24.16	70.40	26.40	120.95	230.00	141.45
45	324.80	4.330	35.53	45.60	2.70	8.37	31.94	89.35	44.23	174.86	280.57	149.94
50	465.00	6.200	53.18	83.36	3.00	10.99	41.87	114.67	66.18	250.90	398.82	214.10
55	505.50	6.740	84.18	142.37	3.30	14.30	54.54	146.35	97.48	357.56	408.00	148.00
60	532.00	7.080	117.88	220.82	3.60	18.55	71.70	186.78	121.48	497.85	410.52	34.15
65	566.00	7.548	153.28	331.40	3.90	23.97	91.35	238.38	163.28	685.10	402.72	—119.10

[1] From "Forest Mensuration of the White Pine," by Harold O. Cook, page 27.

The most frequent criticism that is leveled against forest planting by the individual is that the investor rarely if ever reaps the benefit. This, to a large extent, is true, but short rotations are possible where fence posts, Christmas trees, etc., are raised; and, in addition, the increasing negotiability of half-grown forests is a factor that must be reckoned with. If a man does not care to invest in a forest plantation for the benefit of his children or his estate, he may console himself with the thought that, besides affording him the pleasure of watching the trees grow, the land covered with an embryonic forest will be much more salable than stony fields or scrubby pasture.

Willow Culture. The bulk of forest planting in the United States is done with seedlings or transplants as the stock. These require a considerable outlay in the form of nurseries, and the attention required to raise good nursery stock brings up the cost to a good figure.

Certain species can be propagated by simply planting a piece of young wood, preferably the last season's growth. Species like poplars and willows are frequently propagated in this way. The raising of willow for basket-ware is quite an industry in certain parts of the country. It was introduced into New York by German immigrants between 1840 and 1850, and has since spread to other states. The site best suited for a " willow-holt " is a well-drained sandy loam containing a fair amount of humus. In some regions land subject to annual overflow is chosen, since this obviates fertilization. The American willow produces a tougher and more durable rod, but many European species are used, among which the Caspian and Welsh willows have found great favor.

The sets are planted, either in the spring or late fall, after the growth has ceased, in rows 15 or 20 inches apart, and the sets placed from 5 to 9 inches apart in the row. This takes from 35,000 to 80,000 cuttings per acre.

Cultivation of the holt is practically unavoidable if good growth is desired. If cultivation is difficult, the weeds may be mowed to prevent their choking out the willows. After the stools are established, it is customary to cut the holt over annually. As soon as the leaves fall, the harvesting may commence and often continues through the winter. After cutting, the rods are steamed, dried, sorted, and then packed for shipment.

The yield of willow ranges from 3 to 6 tons per acre. If several cultivations are given, a yield up to 9 tons per acre may be obtained; but experienced growers claim that the product is hardly as desirable as that obtained in the ordinary manner, and prefer a smaller yield of better-grade material. The green rods sell for approximately $20 per ton; steamed, stripped, and ready for manufacture into furniture, baskets, etc., they bring about $30 per ton. With suitable land, capable of being plowed for the prevention of insect and fungus attacks, willow culture is a profitable undertaking, and represents one phase of forest planting where returns are not long deferred.

Trees Recommended for Forest Planting

The experience of the past 30 years has given foresters the background of information as to which trees lend themselves best to the local climatic, soil, and other conditions and as to which trees grow most rapidly and are most free from pest attack. The following list is not complete and there are many variations within each region, but it will furnish a general guide for planting programs now being extensively conducted in many parts of the country. For special conditions of erosion control, shelterbelts and windbreaks, gully repair, etc., special varieties may be locally recommended. However, the following indicate those trees which have proved to be most successful under a wide range of conditions as indicated.

1. For the North and Northeast, from New England and Pennsylvania to Wisconsin, inclusive: white pine, red or Norway pine, white spruce, jack pine, Scotch pine, and, in the southern portions, red oak and tulip poplar.

2. For the Prairie and Great Plains region, from Canada to Texas: ponderosa pine, red cedar, Scotch pine, cottonwood, bur oak, hackberry, Chinese elm, green ash.

3. For the Southeast and South, from Virginia to east Texas: slash pine, longleaf pine, loblolly pine.

4. For the Inland Empire and Northern Rocky Mountain region: ponderosa pine and western white pine.

5. For the Pacific Northwest: Douglas fir, Sitka spruce, Port Orford cedar.

6. For the Central Rocky Mountain region: ponderosa pine, Douglas fir, Engelmann spruce, at the higher elevations, and cottonwood, box elder, and Chinese elm in the valleys.

7. For the Southern Appalachian and adjacent mountainous regions: white pine, red pine, tulip poplar, red oak, and shortleaf pine.

8. For the Northwest Coast of California: redwood and, for the Sierra Mountains and northern California, ponderosa pine.

2nd part

CHAPTER IX

FOREST PROTECTION AGAINST INJURIOUS AGENCIES

Forest protection is that part of forestry which deals with the protection of timberlands against such destructive and injurious agencies as fire, insects, fungi, wind, sand dunes, and minor influences, such as grazing, frost, and sunscald. The most important are taken up in some detail.

Forest Fires

Of all the enemies of the forest, fire is the greatest. It is one of the most serious drawbacks to the practice of forestry in this country in that, under present conditions, it is considered a hazardous risk to hold standing timber. Remarkable progress, however, is being made in fire protection, and at the present time about one-half the remaining standing timber is receiving at least some attention in the matter of protection.

In placing any forest tract under scientific management, it is absolutely necessary first to insure adequate protection from fires. A good portion of our early American forestry practice will be devoted for some time to securing efficient protection of our forests against the destructive waste of forest fires.

It is estimated that in the past the value of standing timber destroyed in this country by fire has been equal to that actually cut down and used. For the past fifty years records of the amount of damage by fire show that an average of $16,000,000 worth of timber has been destroyed every year and that at least 20,000,000 acres of forest land, or an area nearly four times the size of Massachusetts, is burned over annually. To express the amount of damage in another way, if fires had been prevented on forest lands that are now unproductive on account of their destructive work, thirty-two billion b. f., or almost the entire lumber cut in the country, could be produced continuously every year on this area.

During unusually dry years, the losses from forest fires have been enormous, especially in those regions where the timber growth is dense and therefore favorable to the spread and disastrous effects of fires. For instance, in 1894 the famous Hinckley fire in Minnesota burned over an immense tract of timber, wiped out nine towns, killed six hundred people, and destroyed $25,000,000 worth of property. In 1910 forest fires in northern Idaho and western Montana destroyed over $25,000,000 worth of white pine, ponderosa pine, Douglas fir, and western larch timber in the short space of scarcely three weeks.

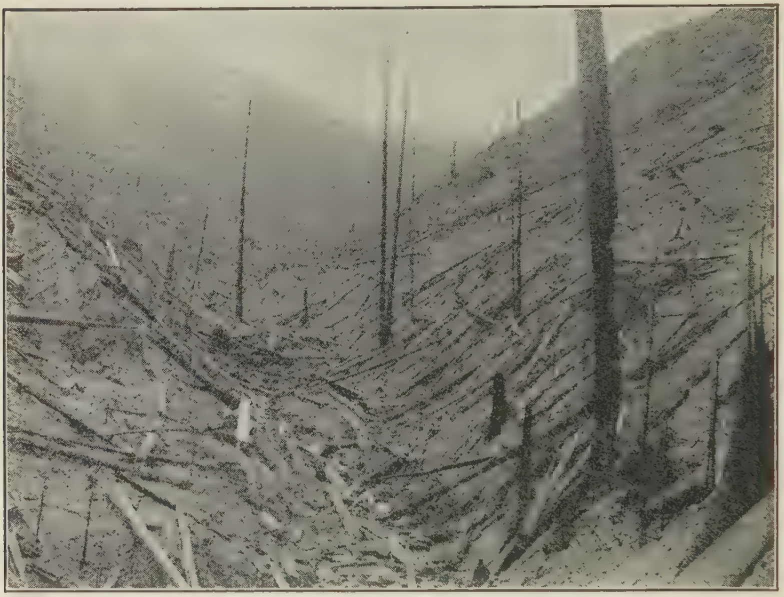

FIG. 76.—Effects of hurricane and fire, Coeur d'Alene National Forest, Idaho.

Kinds of Fires. In general, there are two kinds of forest fires: ground and crown fires. The ground fire burns along in the grass, leaves, or litter on the forest floor, or it may burn

2 kinds of forest fires:
ground

in the thick duff. In the last-named case it may burn very slowly and hold fire for many months, even burning as late as mid-winter in the decayed accumulation of vegetative matter, such as leaves and twigs. Ground fires of this class are sometimes separated as a distinct kind from the ordinary surface fire which burns along on the leaves and twigs above the vegetable mold.

Ground fires are especially common in the open, grassy pine forests of the South and in our hardwood and coniferous forests in the North. They do considerable damage in the farm woodlots throughout the East. When fanned by a high wind and in the presence of sufficient inflammable material, such as brush, fallen trees, and dense reproduction, a ground fire may develop into a crown fire.

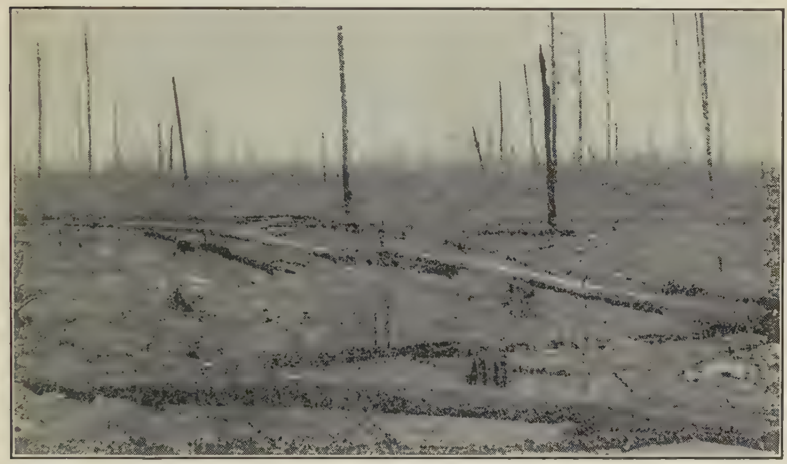

FIG. 77.—Burned-over area, Chippewa National Forest, Minnesota. Only reforestation by planting can properly restore the forest when completely killed by a crown fire.

The crown fire is the more serious kind and burns with great rapidity through the crowns of the trees, often consuming everything in its path up to branches 3 inches in diameter. Such fires occur only in dense coniferous stands or where the principal growth is of evergreen stock. Most conifers are

conifers = member of pine family

coniferous = cone bearing [illegible]

highly resinous, especially in their bark and leaves, and therefore very inflammable. Fires often run up the resinous bark of a tree or through dense underbrush from ground to crown fires. Some of these fires have been known to burn at the rate of 6 to 10 miles an hour. Under the pressure of a high wind, burning brands are often carried ahead of the main fire and ignite new fires in advance. It is practically impossible to stop the progress of a crown fire in a severe wind. Back firing is often resorted to, but more often the crown fire will become a ground fire after passing the brow of a hill or ridge, where it could be stopped by trenching.

The severity of any forest fire depends upon several factors. Perhaps the most important, aside from the character of tree growth, is the dryness of the forest itself. After a protracted drought the fire hazard is very great and a small fire is likely to develop into a serious one, especially in the late summer. Some of our worst fires have occurred in September and October and have only been stopped by a heavy rainfall or because the continuous forest cover was broken by an open plain or agricultural land.

The character of the topography is also a very influential factor. Fires burn with great severity and rapidity up a steep slope, because the heat of the fire itself creates a draft and tends to intensify the progress of the fire. In burning down a slope a forest fire always progresses slowly and burns lightly over the ground, so that it can be most successfully fought and controlled just over the brow of the ridge or at the foot of a slope.

The amount of inflammable material on the ground obviously influences the character and severity of the fire. The spruce woods of the Adirondacks are very brushy and dense and a fire, once started, burns with great heat and rapidity. A fire in hardwood leaves is much less severe than in pine or spruce needles. The soil is also a factor in fire protection. The sandy plains of the east coast and the Lake States dry out with great rapidity on account of their porous nature, and ground fires are prevalent whenever adequate protection is not afforded. In Massachusetts, pitch pine, a very fire-resistant tree, is often the only tree left after repeated fires have burned over the sandy plains. In portions of the Northwest, the clay and loam soils keep the forest floor in a comparatively moist condition and, although the forests are dense and of coniferous species, it is only in excessively dry seasons that flagrant fires are common.

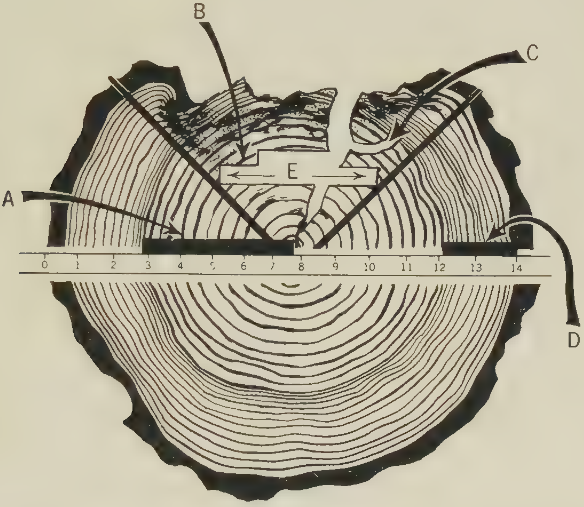

Fig. 78.—How fire slows the growth rate of timber and permits disease and insects to enter through fire scars. *A* shows rapid rate of growth of about 5″ along the radius in 14 years before the fire, compared to *D*, which shows a growth of less than 2″ over a period of 13 years after the fire. *B* shows loss of good wood through disease and decay as a result of fire. *C* shows insect damage and *E* a loss of one-fourth of the log, owing to insects, disease, and the slower rate of growth.

As outlined in these factors, the regions of this country most seriously affected by recurrent forest fires are in the coniferous stands of the Northeast, principally in Maine, New Hampshire and the Adirondacks, the Lake States, and in the dense stands of the Northwest, covered by Douglas fir, western red cedar, western white pine, hemlock, and lodgepole pine.

Grass fires are very common in the southern pine forests, in the ponderosa pine stands of the Southwest, and in the sugar pine-ponderosa pine stands of California. Although not resulting directly in the death of whole forests, they do considerable and irreparable damage by destroying all reproduction and young growth, and by eating away the base of trees until they are blown over by the wind or are attacked and ruined by insects or fungi. Even our hardwood stands are seriously injured by the disastrous work of forest fires. Although pure hardwood forests are never affected by crown fires, the common spring and autumn fires in this class of timber have done an immense amount of damage. This is especially true of our woodlots and small holdings in the Ohio Valley and Middle West, as well as in the more extensive hardwood forests of the East, southern Appalachians, and lower Mississippi Valley.

FIG. 79.--The Civilian Conservation Corps men directly fighting a ground fire in Oregon. The shovel, rake, and axe are some of the best fire fighting tools.

Causes. Ever since the first settlement of this country, our forests have been susceptible to severe fires owing to a great variety of causes. Even before colonial days fires did consider-

[illegible], [illegible] and axe are [illegible] [illegible]
[illegible] tools.

able damage to our American forests. The early settlers often caused many fires in the clearing of land, and no attempts were made to check them. The Indians have started many fires, especially in the West, to drive out game to facilitate hunting. Many grass fires, resulting later in serious forest fires, have been started in the South and West even up to present times with the hope of improving grazing conditions. Altogether about two-thirds of our whole forested area has been burned over at one time or another and much of this has been burned repeatedly.

Although it is very difficult to detect in every case the cause of forest fires, records show that the most important causes are railroad locomotives, careless campers, the clearing of land and the burning of brush, lightning, hunters, and incendiaries. It is a notable fact that of all the many causes of fires, lightning is the only one that is absolutely unpreventable. Burning to improve grazing, sparks from logging machinery, burning over blueberry patches and cranberry marshes are also important sources of fires.

Altogether, sparks from railroad locomotives and logging machinery, such as steam loaders, donkey engines, and cableway skidders, lightning, and careless smokers have been the most serious causes of forest fires. Engines, especially on steep grades, send out great masses of sparks which readily ignite the grass or leaves along the right of way during the dry season. Railroad companies have suffered heavy damage suits as a result of this, and many are now cooperating with state foresters and other officials in clearing their rights of way of all inflammable material, in installing effective spark arresters to prevent the emission of live sparks, and very often in patrolling their tracks during the dry summer season. Some have even adopted oil for use as fuel in mountain and forested regions. Several of our railroads have found the use of oil very economical, especially as it can be transported so much more cheaply than the heavier and more bulky coal. Some railroads, like the Chicago, Milwaukee, and St. Paul, have electrified their mountain divi-

[illegible] (elec.) Sparks [illegible]

smokers lightning

[illegible]

sions both to reduce the losses from forest fires and as an economical measure of operation. Several states now require by law the use of spark arresters, fire patrol, and the cleaning up of the rights of way through forest regions. A few railroads have adopted certain remedial measures and have more than saved the increased cost of the installation and change of equipment in decreased law suits for fire damage. In New Jersey, several of the railroads maintain plowed fire lines paralleling the tracks on either side, at a distance of 100 feet. These fire lines are kept clear of leaves and grass so that if sparks ignite the strip inside the fire line, the fire will stop when it reaches the plowed dirt, unless there is a high wind blowing.

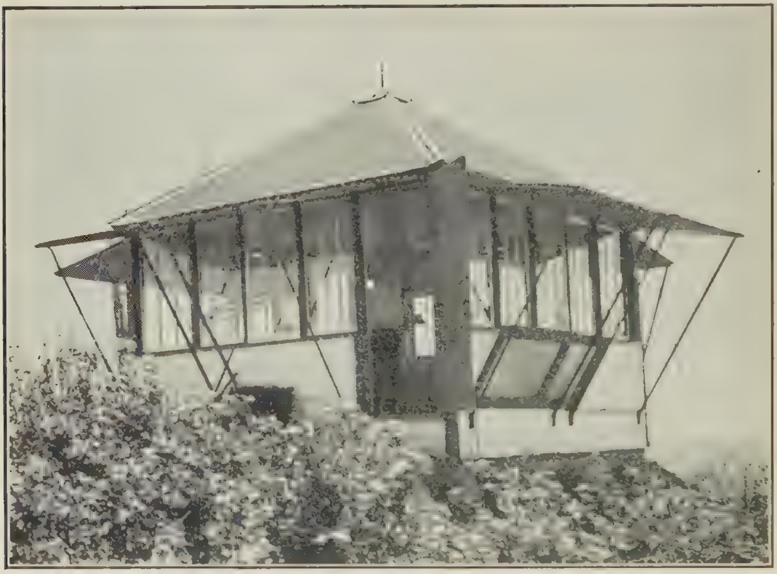

FIG. 80.—Red Top Lookout, Santa Fé National Forest, New Mexico. From this point many square miles of timberland may be observed for fires. A telephone line connects with headquarters of the forest supervisors and men are quickly rushed to the fire.

Spark arresters consist of a heavy iron mesh intended to prevent the emission of large, live sparks. They are placed in the smokestack of the locomotive, and, on steep grades, where they are needed most, they interfere to some extent with the draft, which means of course that it is more difficult to maintain a proper head of steam. At times firemen have driven large holes through the spark arresters or have detached them altogether so that constant inspection has been made necessary in some states to maintain the arresters in condition. However, it may be said that in spite of constant changes and improvements, no spark arrester has as yet been devised or perfected to suit all conditions and circumstances.

Careless campers constitute a very serious fire menace. This is especially true in mountain and forested resorts in Wisconsin, the lake district of Minnesota, the Adirondacks, and portions of the Rocky Mountains and the Pacific coast, which are frequented by campers and visitors during the dry summer season. Many a fire has been started by a lighted match carelessly thrown in the dry leaves. Burning cigars or cigarettes are also a considerable source of forest fires. Perhaps the most serious source, however, is the neglected campfire. Too often a campfire is built against a large or old rotten log where it may smoulder for weeks. Other fires are built in the thick duff and are left in the morning or at night, when a gust of wind may carry a spark a short distance and ignite the inflammable woods. The best way is to build only a small fire and, if it is impossible to find a site free from duff or litter, dig a trench around it so the fire cannot run through the leaves or brush; and to be sure to extinguish the fire on leaving it either for the day or for the night. Fires should always be built in the open and away from any standing or dead trees or any accumulation of dry, inflammable material.

Clearing farm land and burning brush, which always goes with clearing, are common sources of fires in our forest regions. Many states, like Idaho and Massachusetts, now have closed seasons during which it is illegal to burn brush without a permit.

Lightning is a common source of fires, especially where thunder and lightning storms are prevalent. Fires started from this cause have been known to burn for weeks before breaking out into a serious fire. The popular belief that certain trees are more susceptible to being struck by lightning than others does not seem to be substantiated in actual fact. Lightning is especially dangerous when striking an old dead tree or stub. These ignite freely, especially during a dry time, whereas a healthy green tree may not ignite at all.

Our lodgepole forests in the Rocky Mountains have suffered greatly, in the past, from fires set by Indians to improve the hunting. In the South it is customary to burn over the woods every spring in order to improve the grazing conditions for the cattle and hogs. Even in parts of the West this is done to improve sheep grazing.

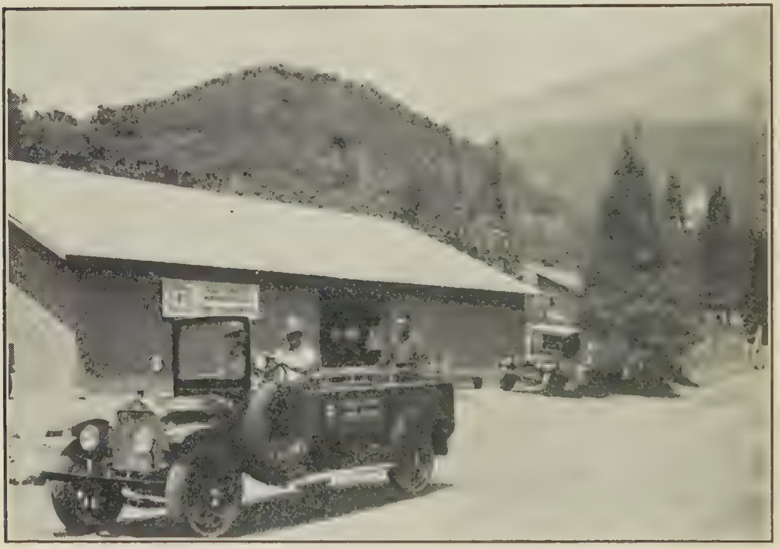

FIG. 81.—Fire truck and Southern California fire equipment warehouse, Angeles National Forest, California. This truck can carry men and tools speedily to the scene of incipient fires and is ready for action day and night during the dry and dangerous fire seasons.

The question of burning over the woods every year to prevent the accumulation of a large amount of inflammable material has been agitated. This is called " light burning " and has as its object the annual disposal of the débris on the forest floor in order to prevent a severe conflagration during an unusually dry season. But this has proved to be poor policy because much injury results to the standing timber and reproduction, and in addition it is very expensive. This has been positively demonstrated in portions of California.

For a recent five-year period, there was an average yearly number of 8676 fires on nearly 200,000 acres of National Forests. Most of these fires burned over one-quarter acre or less. The causes of these fires and percentage of each are shown as follows:

Causes—5-Year Average	Percentage
Lightning	38.54
Smokers	23.91
Incendiarism	13.66
Camp fires	10.03
Débris burning	5.44
Railroads	1.87
Lumbering	1.42
Miscellaneous	5.13
Total	100.00

In recent years, the trend has been toward more fires due to more people going into our forest regions, but with better control, the acreage burned is becoming less and less.

Effects. The effects of forest fires, both direct and indirect, may be summed up under the following heads:

1. *Destruction of standing timber.* The greatest damage resulting from fires is the direct loss of millions of feet of valuable timber. During large conflagrations millions of dollars worth of standing timber is destroyed. If it were possible to cut and utilize this burned timber, much of it could be salvaged, but usually other timber is being cut or facilities are not available to save the remaining standing timber. Contrary to the popular impression, even severe crown fires do not actually consume the large trees. All the branches are usually burned off

and the stem is severely charred, but, if cut within a year or two after the fire, much timber can be saved. Altogether, the greater part of our annual $25,000,000 fire loss can be attributed directly to the loss of standing timber. Surface fires also kill a great many trees, especially in our hardwood regions and southern pineries. Crown fires have done the greatest damage in the northern spruce and pine forests, in the lodgepole pine stands of the Rocky Mountains, and in the dense Douglas fir and white pine and hemlock forests of the Northwest.

2 2. *Indirect losses through windfall, insects, and fungi.* Besides the enormous losses from the direct destruction of valuable live timber, forest fires do considerable damage by eating away the lower parts of tree trunks until the wind blows the tree over or permits the entrance of wood-destroying fungi. This is especially true in the South where the longleaf pine is tapped for turpentine. Fires get into the exposed resinous faces and weaken the tree so that the first strong wind blows it over. Considerable losses have also been occasioned through the entrance of fungi and insects into fire-scarred surfaces of trees. Chestnut, lodgepole pine, ponderosa pine, and our oaks have suffered especially in this respect. Some trees, like Douglas fir, pitch pine, and hemlock, either have thick barks or contain fire-resistant materials, such as tannin, and are thus protected by nature from injury by surface fires.

The longleaf pine seedling protects itself admirably from fires by its thick bushy crown. Even when this is burned off, the vegetative sprout at the tip will start up the following spring.

3 3. *Destruction of seedlings and young growth.* A considerable portion of our fire damage is the destruction of the young trees and reproduction which must be depended upon for the forests of the future. A dense young growth of conifers is especially inflammable in a dry season. Although it has no actual market value, our courts are beginning to recognize the potential or future value of young standing timber and are allowing damages in case of fires resulting from carelessness or negligence. In fact, under our present conditions of extreme

fire hazard, the planting of new forests or expensive provision for natural reproduction is not warranted unless adequate fire protection is assured.

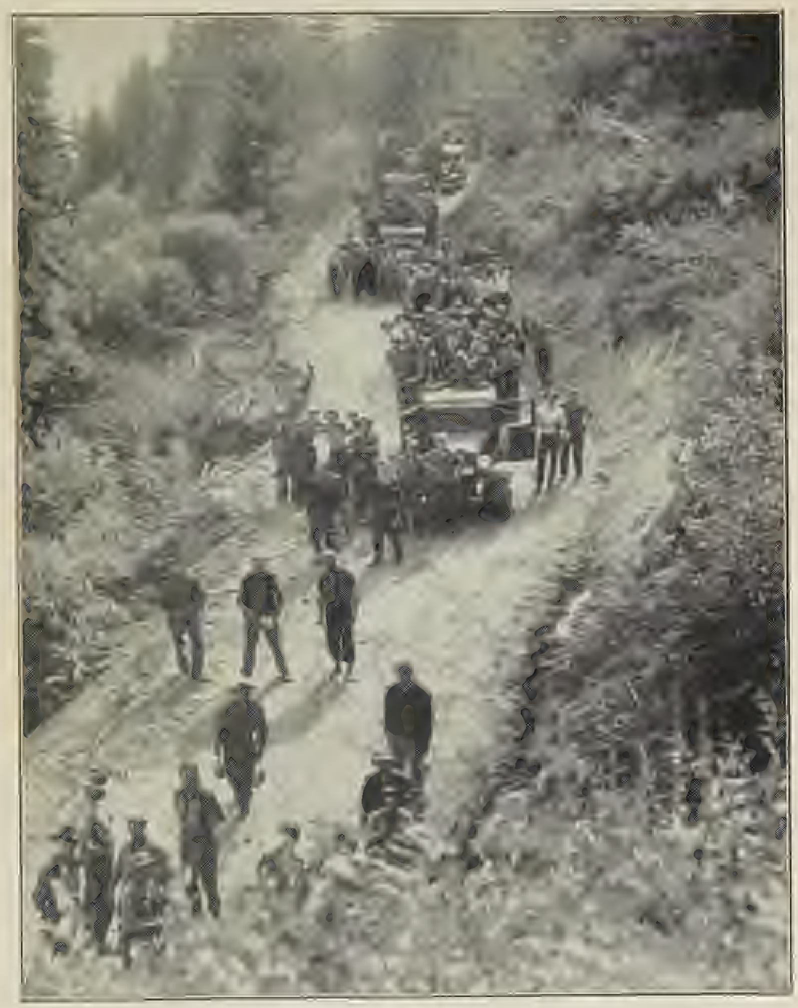

FIG. 82.—A convoy of motor trucks carrying Civilian Conservation Corps men and equipment to fight a fire in the Northwest. Speed in getting men and equipment to the fire is a most important factor in the forests as well as in the city.

4. *Injury to the soil and streamflow.* As explained in the chapter on silvics, trees depend for their food, and therefore their growth and vigor, on certain constituents of the soil, supplied from decayed leaves, twigs, etc., as well as from the mineral salts. If the humus and soil cover are destroyed, the soil is impoverished and a poor forest results. A severe fire will frequently burn out a thin soil down to the bare rock or at least to the hard mineral soil. This is especially the case in mountainous regions. It may take hundreds of years to bring back the soil to its normal condition and fertility. As the forest builds up the soil, it depends upon it for its best growth. In this same connection, it is apparent that after a fire the forest largely loses its function to prevent rapid run-off, with consequent erosion of the soil, floods, etc. Many of our floods, especially in western Pennsylvania and the South, may be attributed to the work of fires as well as denudation from lumbering.

5. *Loss of life and general business.* It is estimated that several thousand lives have been lost in forest fires in the past fifty years. Whole towns have been wiped out of existence, together with many of their inhabitants. This great loss of property has prevented in some cases the settlement of new regions. Even in recent years about seventy lives, on an average, have been lost in forest fires every year.

Many mountainous sections which have served as attractive summer resorts and recreation grounds have lost their attractiveness on account of fires. Even considerable game and fish have been destroyed by the fires. Many areas have reverted to the state through non-payment of taxes as a result of forest fires, and this direct economic loss has been enormous in portions of the Lake States, especially Michigan, and in the South. For every dollar's worth of timber burned, it is estimated that several dollars in wages that would otherwise be expended in logging and manufacturing are lost.

Methods of Prevention. In Europe the annual fire losses are less than 1% of all the forested area, and all the forests are under some systematic plan of fire protection. In this country about one-half of our total forested area is now receiving at least some attention in the matter of fire protection, whereas only a few years ago less than 2% received any protection.

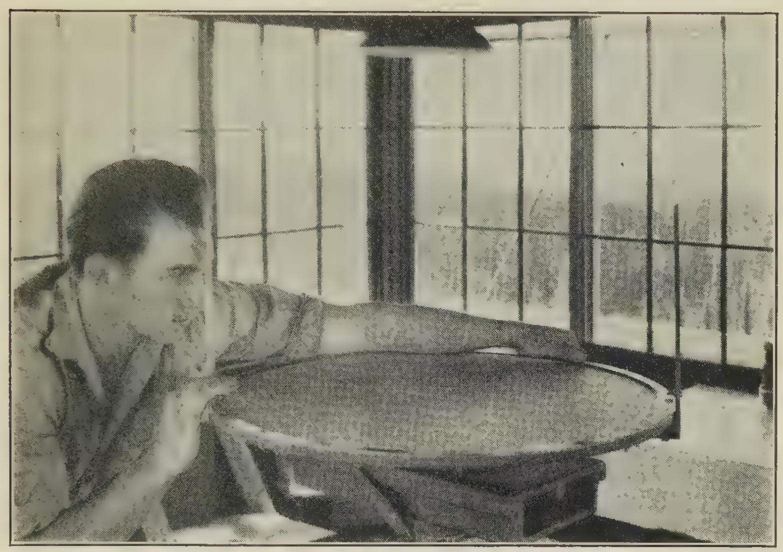

FIG. 83.—A forester sighting along an alidade to a forest fire. The circle encloses a map on which is shown the ridges, drainage areas, and other topographic features which help him in locating a fire before reporting it by telephone. Taken in northern Idaho.

Our National and State Forests are now being organized under efficient plans of fire protection. Even the lumbermen and timber owners are uniting in protective associations and providing for a definite system of fire prevention. Large tracts of timber are now being successfully protected at an annual expenditure of from 2 to 4 cents per acre. Some associations of private owners have spent as high as 10 and 15 cents per acre in protecting their holdings against fires, and they consider this an excellent forest fire insurance.

The principal methods of fire prevention include the construction of permanent improvements, such as roads and trails, to facilitate the work of getting over the forests and in stopping the spread of fires, lookout points and observation towers, and telephones connecting them with the nearest town and fire warden. In dangerous seasons, fire guards or patrolmen are engaged to patrol the areas and watch for fires from lookout points or towers. In the clear atmosphere of the West, fires have been detected from 50 to 75 miles distant. In the East, fires have been detected up to 30 miles away. Railroads are building fire lines and clearing up their rights of way, and spark arresters and efficient ash pans are being installed where oil is not used for fuel. The occurrence of inflammable brush and slash after logging operations has been a serious fire menace. The United States Forest Service now requires the disposal of brush on most of the timber sale operations on the National Forests. Piling and burning the brush has given excellent results. In some forests, lopping and scattering the brush is required. When this is done, the brush soon rots and the damage from fires is greatly decreased. New York and Minnesota now require by law the disposal of brush by lopping or piling, even on private logging operations.

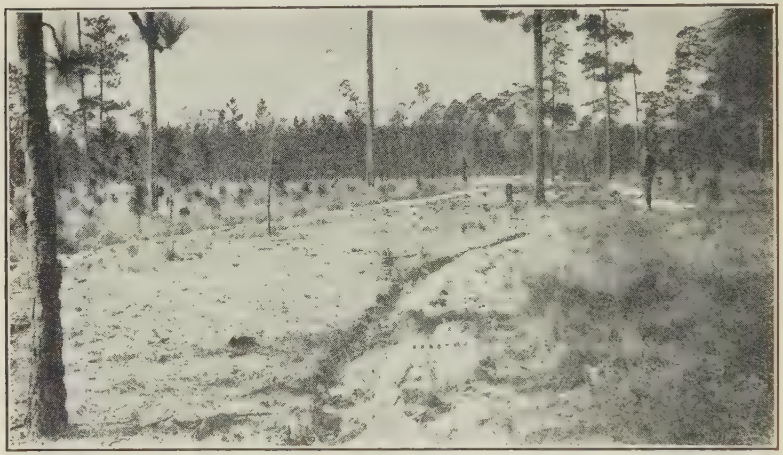

FIG. 84.—Thirty-foot burned fire lane through second-growth longleaf and slash pine stand. Treutlen County, Georgia. These lanes are very effective in stopping surface fires. Furrows are first plowed on each side of the lane, which is burned during the late afternoon or evening, or when the wind is not blowing.

By eliminating the inflammable grass, grazing has also proved to be an efficient aid in the prevention of fires, especially in portions of the West and South where grass fires are common.

Methods of Control. The method of controlling forest fires varies almost with every large fire. In general, however, small surface fires can be beaten out with wet brush or a wet blanket or by simply throwing dirt on them. Large surface fires are best controlled by cutting out a fire line and trenching to the mineral earth well in advance of the fire. They are best fought just over the brow of a hill and at night when the atmosphere is damp. Some of these lines must be many miles in length to check effectively the progress of the fire. Crown fires are only fought by back-firing or waiting until they become surface fires. Under the presence of a high wind it is almost impossible to stop crown fires. The shovel, axe, saw, and sometimes the rake and the mattock are the best tools used in fire fighting. Water is being frequently used owing to the development of better pumps and long hose lines to carry it to the fire. Caches of tools, food and camp supplies, distributed at strategic points over the forest, are now being used with great success on our National Forests.

Historic Forest Fires. As forests were early regarded as barriers and perhaps menaces to the progress of civilization, it was customary to burn them without regard for the future. More trees have been destroyed by fire than by the axe. History is replete with stories of fires that have done enormous damage in many parts of the country. Huntington has shown from fire scars on the California big trees or sequoias, that great fires raged in the year 245 and again in 1441 and in 1797. Studies of Engelmann spruce show that extensive fires occurred in Colorado in 1621, 1722, and 1781. White spruce in Maine indicates that a vast fire ravaged some 200 square miles in 1795.

In more modern days there are records of some terrific fires with loss of life and property, destruction of communities, valuable timber, railroads, etc., and the resultant deterioration of the soil for the growth of future forests.

The following are among the more important historic fires:

1. The Miramichi fire of 1825 in Maine and New Brunswick burned over 3,000,000 acres and took a toll of 160 lives.

2. In 1846, the Yaquina fire in Oregon covered 450,000 acres and destroyed some of the heaviest stands of Douglas fir, Sitka spruce and western red cedar to be found on the west coast.

3. In May, 1853, the Pontiac fire in Quebec burned more than 1,600,000 acres.

4. The Silverton fire of 1865 and the Coos fire of 1868 in Oregon burned over 1,000,000 and 300,000 acres respectively. In the latter year the St. Helen's fire burned more than 300,000 acres in Washington.

5. The famous Peshtigo fire of October, 1871, in Wisconsin burned over 1,280,000 acres, destroyed farms, villages, lumber camps, and railroads. More than 1500 people lost their lives.

6. In 1881 a fire burned 1,000,000 acres in Michigan with a property loss of $2,000,000; and 138 people were said to be burned alive.

7. The great Hinckley fire of Minnesota in 1894 resulted in the loss of 600 lives; 12 towns and villages were completely destroyed; and 160,000 acres of forest burned.

8. From April to June, 1903, more than 450,000 acres were burned in the Adirondack Mountains in New York, resulting in vast property losses and the ruin of large numbers of families.

9. In 1910 came a series of the worst fires in any one year. These occurred in Minnesota, where 300,000 acres were destroyed and 42 lives lost, in Oregon, in Washington, and in Idaho. Smoke was sighted 300 miles out in the Pacific Ocean. A haze interfered with nautical and land observations for many days. In August, 1910, the worst of these fires occurred in Idaho. Over 2,000,000 acres of valuable western white pine timber were burned, 85 lives lost, and many villages and communities destroyed. After a drought of three months, dry lightning storms set fire to the woods. Over 3000 fire fighters were at work. Over 3000 small fires had been put out in northern Idaho and western Montana. On August 20 a hurri-

cane raged for 24 hours. Small fires were fanned into large crown fires and flames jumped rivers and raged unchecked for weeks. About 75 men were burned to death when the fire swept over a strip 120 miles long by 20 to 30 miles wide. Forest ranger E. C. Pulaski performed one of the great heroic deeds in the history of American forestry. He led 45 fire fighters, trapped by the fire, into an old open mine tunnel and hung wet blankets over the entrance. Flames swept the opening. Heat, smoke, and gases caused a panic among the men. With a revolver Pulaski held his men back to save them from themselves. Finally he collapsed, and one man escaped to be promptly burned in the flames. After two hours, the remainder of the party emerged unscathed.

10. In October, 1918, after a shortage of 20 inches of rainfall in 20 months, the great Cloquet fire raged in Minnesota. A cigarette was thoughtlessly thrown into the brush or a camp fire carelessly left to burn unquenched. This important sawmill town of 12,000 people was completely wiped out. Property and timber worth $30,000,000 were destroyed and the city of Duluth seriously threatened. Over 400 lives were lost in that region.

11. In 1932 a fire over 32 miles long and 8 miles wide covered 220,000 acres on the Santa Barbara National Forest in California.

12. The great Tillamook fire of 1933 in western Oregon burned for 10 days and destroyed 267,000 acres of valuable giant virgin timber estimated to contain 12,000,000,000 b. f., or more than was cut in the whole country during 1932. The estimated loss to industry, the public, labor, villages, and timber was $350,000,000. Stumpage value alone was $20,000,000. This represented about 8 times as much timber as was cut in the whole Pacific Northwest region in 1932. More than 3000 men fought this fire, including many from the Civilian Conservation Corps camps.

Owing to the larger numbers of people going into our timbered regions, more and more fires are being started; but with the improved protective methods and devices the fires are being more promptly checked and stopped and, therefore, the losses are gradually becoming less and less.

Needs

Forest Insects

Although working in a more insidious and less visible way, insects have done an enormous amount of damage to our American forests. It is estimated that the western pine beetle killed over one billion b. f. of timber — practically all the mature trees in the Black Hills of South Dakota — in the ten years from 1898 to 1908, causing a loss of $2,500,000.

Our forests have been attacked rather sporadically by these insects, of which there are thousands of species. The most serious damage, however, has been done by a comparatively few species. Some attack only living trees; others confine their work to dead and dying trees; still others do great damage to sawed lumber and various wood products. Many of the insects limit themselves to certain tree species. Very often, dead or fire-killed timber would remain sound and could be used

Fig. 85.—Cutting down and eliminating insect-infested ponderosa pine in California. The men of the Civilian Conservation Corps have materially reduced the damage by insects and disease in many parts of the country.

several years after dying, if it were not for the destructive work of beetles or insects of some kind. Sawed logs or pulpwood should not remain long in the woods in the summer or they may be riddled and ruined by wood-boring insects.

Most of these attacks have been fought and curtailed by felling the insect-infested timber; by using the logs for lumber or other purposes; and by burning the tops, bark, and other parts that may be infested with the larvae, eggs, or even the adult insect. Infected timber should usually be felled and treated during the winter or at the season of the year when the adult, larvae or eggs will be disposed of. Spraying with a poisonous solution such as arsenate of lead, has been used with success in the East in controlling leaf-eating insects, but it is not applicable to large forest tracts.

Some of the most dangerous species of insects and their work are described as follows:

1. The gypsy moth (*Porthetria dispar*) and the brown-tail moth (*Euproctis chrysorrhœa*) were both accidentally introduced from Europe and have spread with alarming rapidity over eastern New England. They eat the leaves of both fruit and forest trees, with the exception of most of the conifers, and have done an immense amount of damage. Already about $7,000,000 has been spent in fighting them. Massachusetts has appropriated annually, for a number of years, over $200,000 to suppress them, but they are still spreading. They have been held in check to some extent by spraying, by destroying the egg masses, and by the introduction of parasites to feed on them. Strong efforts are now being made by the government authorities and the states involved to prevent the spread of these two insects to New York and the adjoining states.

GYPS
MOTH

BROWN
-TAIL
MOTH

2. The southern pine beetle (*Dendroctonus frontalis*) is one of the most dangerous insect pests in the country. It first became noticeable in 1891 when it spread over West Virginia, Virginia, and North Carolina, killing millions of feet of valuable spruce and southern pine. Since 1902 it has been found in various parts of the South as far west as Texas and has broken

SOUTHERN PINE BEETLE

out in intermittent attacks in the extensive pine forest of the Southeast.

3. The spruce beetle (*Dendroctonus piceaperda*) has been prevalent in New England and New York since 1818, in some places destroying many square miles of valuable spruce timber. It has, however, been rather sporadic in its attacks. By cutting out infested bodies of timber, it is estimated that on one tract of timber there was an actual saving of over $100,000. Another species of this beetle has done great damage in the Engelmann spruce of the Rocky Mountains.

PRUCE
ETle

Other prominent examples of insect attacks are those of the locust borer, which riddles both the heart and the sapwood of the black locust, discrediting this valuable tree for planting by railroads; the white pine weevil; the catalpa sphinx; the larch sawfly; the hickory bark beetle; the powder post beetle; and a great variety of others.

Fungi

A number of fungi have also done considerable damage to both living and dead timber, and in some regions enormous losses have occurred. Among the most serious attacks may be mentioned the following:

1. The chestnut bark disease (*Endothea parasitica*) was first discovered in 1904 near New York City, and it has now spread over nearly the entire range of this valuable tree. In some places, especially in southeastern New York, New Jersey, southern New England, and eastern Pennsylvania, it has killed every chestnut tree, its attacks being confined to this species. The fungus works in through the bark, encircles the tree just beneath the cambium layer, and eventually kills the tree by cutting off the circulation above that point. Its seeds or spores are scattered by the wind, birds, and animals, and it is estimated that it has already done more than $25,000,000 worth of damage. No effective means of checking its spread has as yet been discovered, and it is problematical as to whether or not it will eventually kill all our native chestnut trees. In forest man-

agement, where the disease is prevalent, other species should be encouraged as against chestnut.

2. *Trametes pini* attacks practically all the important conifers and it is a very common and serious disease. It enters the wood through wounds or fissures in the bark and causes a destructive rot in both the heartwood and sap. It is spread in the same manner as described above. No means have been devised to fight it; but, when discovered, diseased trees should be cut and removed if possible. This will result in greatly lessening the liability of loss from this cause.

A number of others of the Polyporus family, the white pine blister rust and others, have done great damage to our forests.

3. *Dutch Elm Disease.* The Dutch elm disease was first discovered in Ohio in 1930 and since has been found on elms in New York, New Jersey, Connecticut, Maryland, and Indiana. It has proved to be very destructive. It is caused by a fungus which lives in the sapwood of the elm and is detected with the wilting and death of the leaves and the later drying and cracking of the bark. Still later a brown discoloration appears in the sapwood.

A federal laboratory has been established at Morristown, New Jersey, to study this disease. Many thousand elm trees have been cut and destroyed in the region of New York City and considerable federal funds have been made available to combat the disease.

Grazing

Grazing may be classed as an injurious agency when not properly regulated. Goats, sheep, and cattle may prevent the forest reproduction either by tramping the trees under foot or by nipping off the tender young shoots. Our woodlots especially have suffered in this respect. When cattle are turned into a wooded area, the young growth is soon destroyed. Sheep and goats have also done a large amount of damage to our forests in the West. On our National Forests, however, this matter is being properly regulated and in some cases grazing may be used to advantage in stirring up the soil and enhancing the chances for a successful germination of seeds in reproducing forests. Woodlots should be devoted either wholly to pasturage purposes or to the growth of wood products.

Sand Dunes

Blowing and shifting sands have done considerable damage on our eastern and western coasts, as well as in other sections, by covering up younger or even mature forests, valuable farm land, and other property. The sands can be fixed and held in place by the planting of grasses and trees. France has spent many millions of dollars in the fixation of sand dunes in Gascony.

Miscellaneous

A number of other agencies injurious to forests have called forth certain protective measures in forest management. Among these agencies may be mentioned windfall, frost and sun cracks, damage from snow and ice storms, injurious effects of smoke or gases, and the attacks of animals. For instance, porcupines have killed thousands of lodgepole pine trees by girdling them at the base. Deer often nip off the ends of tender young seedlings, and rodents commonly preclude the possibility of reproduction by consuming all the tree seeds in certain localities.

Most of the causes of injury mentioned may be properly treated in the silvicultural management of forests. As an example, where trees are susceptible to windfall, the stand should not be sufficiently opened up or trees left standing alone so that they will be blown down by the wind.

Early or late frost may do much harm to certain species, especially in the seedling or young stages, both by freezing them and by heaving them out of the soil. The following species are especially susceptible to frost killing: black walnut, hickory, ash, beech, catalpa, a few oaks, fir, and ponderosa pine. Among the frost-hardy species may be mentioned birch, poplar, willow, maple, spruce, redwood, red cedar, and Scotch pine.

Frost cracks are long splits caused in the stem of trees by the contraction of wood due to severe winter cold. They are followed by long projecting ribs on the tree, called frost ribs. A sudden fall of temperature is especially harmful. Hardwoods with large medullary rays, such as oak, beech, and sycamore, as well as elm, ash, and chestnut, are most susceptible.

CHAPTER X

MEASURING THE GROWTH AND YIELD

General. Forest mensuration may be defined as the measurement of the contents of logs, trees, and standing timber and the determination of growth and yields.

Under the present economic conditions the measurement of the forest crop is of increasing importance, since, with the rise of stumpage values, accurate estimates of the contents of timber tracts are necessary. In addition, many of our progressive lumbermen and pulp manufacturers are now figuring on sustained yield from their forest land, so that the study of growth

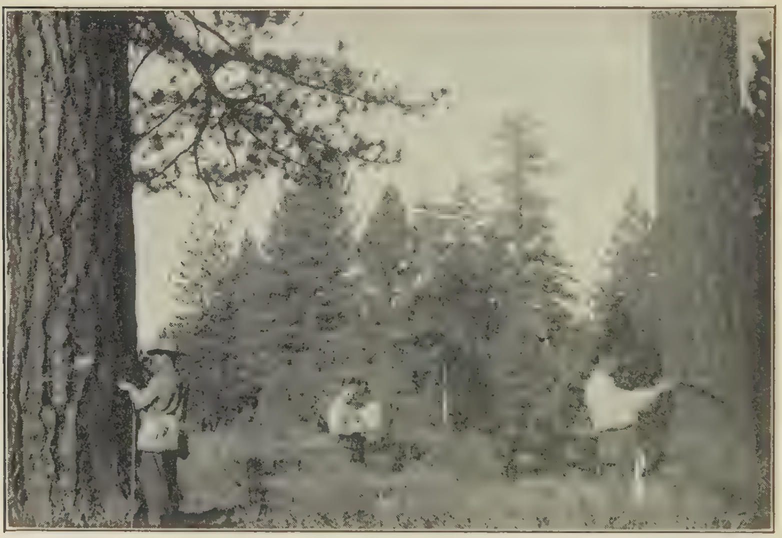

FIG. 86.—Foresters cruising ponderosa pine timber in California. On the right, the diameter is being measured with a Biltmore stick; on the left the diameter is measured with a tape; the forester in the center is keeping the records. These two old veterans in the foreground will be cut and the growing space left for the younger trees and reproduction already started on the area.

and yields is also of importance. Until the last few years it was customary to buy large tracts of timber on the ocular estimate of an experienced cruiser. Now, progressive lumbermen insist on an accurate survey, as they cannot afford to risk the chance of large error. Consequently, scientific methods are replacing the old ocular estimates, and although at present volume tables and yield tables are by no means complete, much progress has been made

Units of Measurement and Equivalents

There are many units used at the present time in measuring timber. Among them may be mentioned the board foot, the cubic foot, and the cord. Of these the board foot is the unit most commonly used.

A board foot consists of a board one foot square and one inch thick. This unit has attained wide use in America, since it gives an idea of the amount of lumber actually used; but it is by no means scientific or accurate when the entire contents of a log are sought.

B. F.

A cord is a stack of wood 8′ long, 4′ high, and 4′ wide. It contains 128 cubic feet gross but, on account of the air spaces between the component pieces, may range anywhere from 70 to 102 solid cubic feet of wood. Various factors affect the solid contents of a cord. Split wood takes up more room than the same amount before splitting. Long limbs permit of more air space because of the crooks. Logs of large diameter permit less air space between them.

8/4/4
CORD

The tendency of wood to shrink in seasoning from 12 to 14% must be kept in mind; consequently, the bulk of a long rank of cordwood may be diminished by that amount after standing one season in the woods.

Pulpwood, excelsior, shingle and heading bolts, and fuelwood are the kinds of materials which are mostly sold by the cord, and the dimensions may vary somewhat for these different products. For instance, in some parts of the country a cord may be 5′ by 4′ by 8′, making altogether 160 cubic feet, gross.

In addition we have various forms of short cords and stovewood. Either 18-inch or 2-foot lengths may be used, and the price varies according to the actual solid contents. A standard cord is considered to yield from 350 to 600 b. f., depending on the size of the logs, with 500 b. f. as the average.

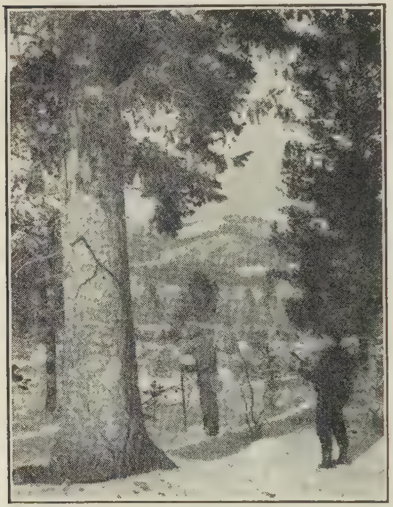

FIG. 87.—Forest ranger on a timber survey to estimate the present and future yield of the forest.

The cubic foot is not widely used at the present time in the United States, being confined largely to measuring mahogany and other precious woods. With the increase of stumpage values, however, it is generally believed that the cubic foot will be a more common unit since the timber owner will insist on being paid for all this stumpage rather than make a generous allowance for slab and poor manufacture as has been done in the past.

The following equivalents are generally recognized by the Forest Service:

B F ?

1 cord of wood 4′ × 4′ × 8′ = 500 b. f.
1 railroad tie 7″ × 9″ × 9′ = $33\frac{1}{3}$ b. f
1 cubic foot = 6 b. f.
1 post, 4″ × 5″ × 7′ = 3 b. f.

For converting foreign units the factors are as follows:

1 cubic meter = 35.316 cu. ft. or 1.308 cu. yd.
1000 cu. ft. sawed lumber = 2.36 cu. meters sawed lumber
1 cu. meter per hectare ($2\frac{1}{2}$ acres) = 14 cu. ft. per acre.

Log Rules

Log rules are tables giving the contents in board feet of logs of different diameters and lengths. Between forty and forty-

B.F. = board 1" sq. & 1" thick.

five different log rules are used in the United States and Canada, since different rules are favored by the lumbermen in various sections.

The Doyle rule, for instance, is the official log rule in Louisiana, Florida, and Arkansas, and the Scribner rule has received state sanction in Minnesota, Idaho, Wisconsin, and West Virginia. The Scribner rule is the official rule of the United States Forest Service. The Spaulding rule is used in California. The Drew rule is used in Washington; and Vermont and New Hampshire each have a state rule.

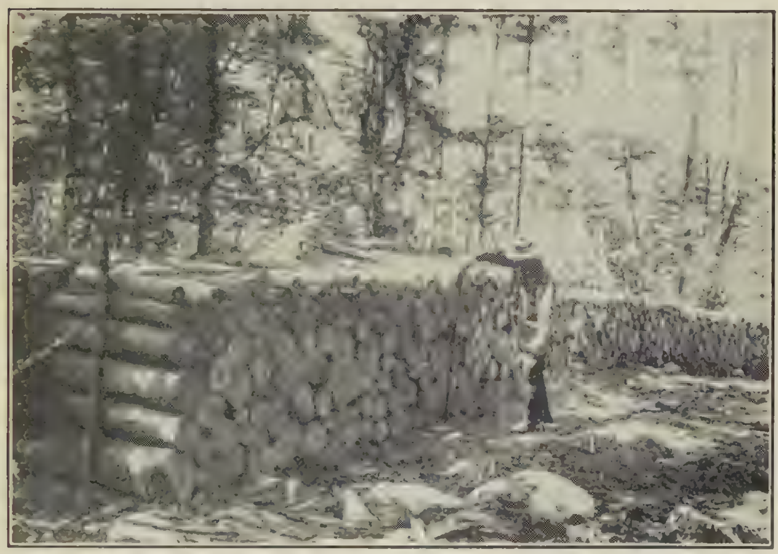

FIG. 88. A forest officer scaling spruce pulpwood corded on the White Mountain National Forest of New Hampshire. This pulpwood is ready for hauling to the nearest pulp mill, or landed at a stream waiting for the spring drive.

The log rule was first mentioned in the lumbering literature of the United States in 1825, and the formula given at that time was practically the same as that of the Doyle rule which came out between 1870 and 1880.

Methods of Construction. Log rules are generally computed in one of two ways, either by formula or by diagram, although good rules based on mill tallies have been made. Of the formula rules, the Doyle, Champlain, and International are the most widely known; and among the important diagram rules, the Scribner and the Maine rules may be mentioned.

The Doyle rule is made on the following formula: Deduct 4″ from the diameter of the log at the small end for waste, square one-quarter of the remainder, and multiply by the length of the log in feet. This will give the contents in board feet. The allowance of 4″ is for slabs, sawdust, edgings, etc., and is extremely liberal for small logs, making the Doyle rule highly conservative for any but large-sized logs.

The International rule is one of the best from the standpoint of theoretical construction, but so far it has not been widely accepted by the lumbermen. It is designed to give volume of logs cut with a band saw, cutting $\frac{1}{8}$-inch kerf, and to allow for shrinking, seasoning, waste, and normal crook. The rule was scientifically computed by mathematical formula and has been checked by mill measurements. Even more accurate than the International is the Tiemann log rule, which is based on actual mill tallies based on a $\frac{3}{16}$-inch saw kerf, and the results smoothed by curves. Neither the Tiemann nor the International log rule, however, has been accepted by lumbermen to any extent.

The Scribner is by all odds the most important of the log rules based on diagrams. It was made by drawing a diagram to scale, showing the width of boards that could be cut from logs of different sizes, the diameters being taken at the small end inside the bark. It gives fair results for small logs, but for large logs over 28″ in diameter the results are too small. However, it was figured that defects in large logs coming from trees that might be over-mature might be allowed for in this way. The Scribner rule — as Scribner Decimal *C* (*i.e.* calling 104 b. f. 10 and 110 b. f. 11, etc.) — has been adopted by the Forest Service for use in timber sales and has given satisfaction.

The Scribner rule has been combined with the Doyle rule to make the Doyle-Scribner. Doyle values are used up to 28″

and Scribner values above, the most conservative portions of both rules being used. As a result the amount actually obtained by sawing up the log may " overrun " the log scale considerably, to the profit of the manufacturer.

The Maine or Holland rule is also based on diagrams and allows for boards down to 6″ in width. It is designed for small logs and is very satisfactory for them. However, it leads to wasteful lumbering if applied to long logs, as a jobber or contractor will cut in lengths favorable to him regardless of the waste that ensues. The Maine rule is considered the best practical rule in use.

A third classification might be made with standard rules, in which the logs to be measured are compared to the contents of a log of a given size. The New York Standard rule is the best known of this type and is quite commonly used in the spruce operations in the Adirondacks. Here the unit is a log 13′ long and 19″ in diameter at the small end. This standard or " market " contains about 192 b. f. and the converting factor used in the Adirondacks is 5 markets or standards per m. b. f. or 3 markets to the cord. To reduce a log of any dimensions to standards, its length and diameter at the small end squared are compared to the dimensions of the standard as follows:

$$\text{Volume in standards} = \frac{D^2}{19^2} \times \frac{l}{13}\cdot$$

This log rule is quite accurate in measuring pulpwood or wherever the entire volume of the stick is used.

The New Hampshire or Blodgett rule is based also on a standard, the unit in this case being a log 1′ long and 16″ in diameter. The statute sanctioning this log rule states that there shall be 1000 b. f. to every 100 Blodgett feet. This, however, does not hold, as the lumbermen find that there are 115 New Hampshire feet per m. b. f. when the diameter is taken from the middle of the log, and 106 when taken at the small end. The formula used when converting logs into New Hampshire feet is as follows:

$$V = \frac{D^2}{16^2} \times \text{length}.$$

In converting standard units into board feet it is not possible to get an accurate result by using the same equivalent for all logs regardless of size. Small logs yield considerably less lumber when sawed than large logs, owing to larger proportion of slab and sawdust; hence different factors should be used.

Relative Values and Discussion. Widely varying results may be obtained by scaling the same skidway with different log rules, owing to the different values that are given by different scales for logs of the same size. A brief comparison of the various log rules in use can be made as follows:

CONTENTS IN BOARD FEET OF 16-FT. LOGS OF DIFFERENT DIAMETERS AS GIVEN BY VARIOUS RULES

Rule	Diameters			
	6″	16″	26″	36″
Scribner	18	159	500	923
Doyle	4	144	484	1024
Holland (or Maine)	20	179	507	1026
Cumberland River	..	121	320	685
Derby	28	195	512	977
International	20	200	555	1085

Log Scaling. Log scaling is the measuring of logs by a given log rule or log scale. It is generally done by one man although two men may work together. The scale stick is applied to the small end of the log inside the bark, the length of the log is ascertained, and the contents, as given by the rule used, are recorded. The scale rule is generally a straight piece of hickory tipped with a plain binding of brass or iron and is marked with figures, showing the contents of logs of different diameters and lengths. Sometimes a caliper scale is used where the diameter is measured at the middle of the log. Under these circumstances the jaws of the calipers are generally sprung slightly to make a deduction for the bark. This deduction, of course, is the same for trees of all ages and thicknesses.

SKID WAY =

The lengths are taken ordinarily in standard even lengths of 8 to 20′ and an overrun of from 2 to 5″ is made in order to allow for the loss by checking, as the log seasons, or "brooming" in the drive. In some cases there is an enormous waste of valuable lumber owing to excessive allowance. For getting the length of the log, a pole or tape is commonly used, although a wheel having 10 spokes, 6 inches apart, is sometimes used. Every time the colored spoke of the wheel running along the log comes down, 5′ have been measured and the length of the log may be easily ascertained within 6″. An experienced scaler can estimate the lengths quite accurately by eye. In scaling, the diameters are ordinarily rounded to even inches and a log 9.8″ in diameter would be scaled as a log of 10″; a log 11.4″ would be scaled as an 11-inch log.

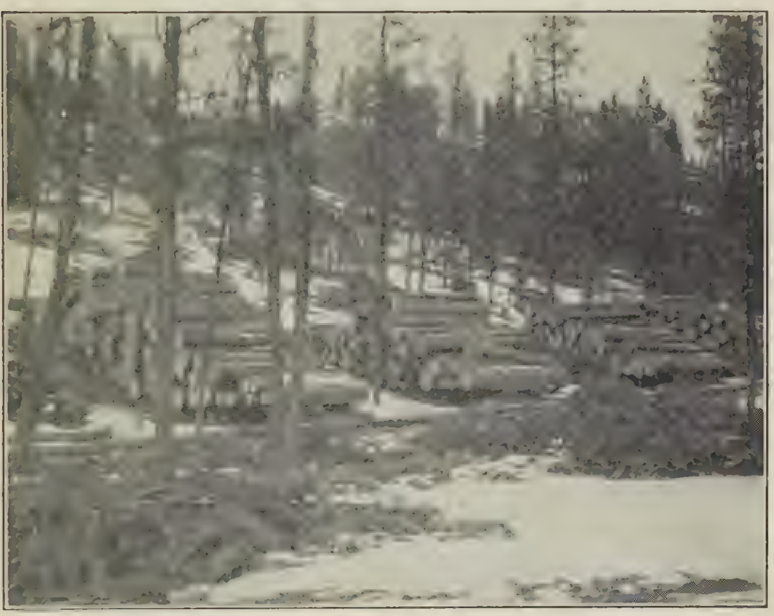

FIG. 89.—Landing of excellent ponderosa pine logs decked ready for scaling at head of branch chute awaiting transportation to the sawmill. Scalers generally measure the contents of logs in board feet at such landings.

The results to be obtained in scaling are very largely dependent upon the personal equation and the care exercised by the scaler. Some scalers are extremely conscientious and will endeavor to measure the length of each log; others may guess the contents of a log without using the scale stick at all. Two conscientious scalers working independently may get different results on the same skidway when the same log scale has been used, the difference being due to allowance for defects, etc. The cost of scaling ordinarily ranges from 5 to 15 cents per m. b. f.

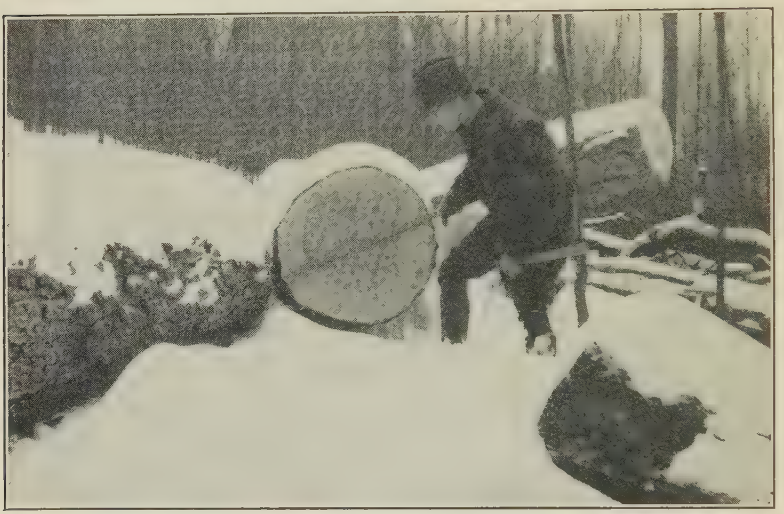

Fig. 90.—Ranger scaling sugar maple logs on the Alleghany National Forest. The scale stick indicates the content of the log in board feet.

Volume Tables

A table of contents for a given species, showing the number of board or cubic feet in trees of different sizes, is called a volume table. The contents given are average only and, although they will hold true in computing the contents of an entire stand, they may not give a true result for any single tree.

Kinds. Volume tables are of different kinds, the most important of which are:

First. Volume tables based on diameters alone. In this type the contents are considered to be a function of diameter only. It is the simplest form of volume table, easy to make, and ordinarily the first to be used. When not used outside the region for which it was intended such a table gives fair results.

Second. Volume tables based on diameter and total height of the tree. Under this heading may be grouped those volume tables in which the contents for trees of different total heights or for different used lengths are given. There are several forms of this type of volume table, such as those based on diameter and merchantable lengths and the volume table based on diameter and tree classes. The most widely used, however, is the volume table based on diameter and classified heights.

Third. Graded volume tables. This table is the only one which shows quality as well as quantity produced. As the name indicates, such a table gives the amount of lumber of each grade that can be sawed from trees of different sizes. A few such tables have been made and, when care is taken in constructing them, they are extremely valuable since they give the exact value of each tree as it stands in the woods. Because of the fluctuation in price and grades and the variation in sawing practice, such tables need constant revision and can be used effectively only with valuable woods and where intensive management prevails.

Construction. The graded volume table is made by following a tree which has been measured and numbered through the mill, log by log, and recording the amount of timber of each grade that is obtained. The contents of all trees having the same diameter are averaged and any irregularities are evened off by a curve.

The volume table based on diameters alone is made by scaling a large number of trees (500 will serve if taken with care, but 1000 trees are better) and then plotting the contents on cross-section paper, diameter on age. A curve is then drawn to strike an average and the values are read from the curve.

The table based on classified heights is rather more complicated but the underlying idea is the same. The data are best secured on a large lumbering operation where the large number of trees felled permits the rejection of any specimens that deviate from the normal. A crew of three men is most effective and the equipment needed consists of calipers, tape, scale stick, and notebook or tally sheet. The steps are as follows:

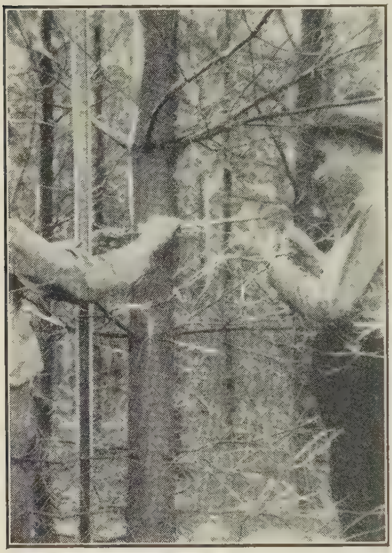

Fig. 91.—Foresters measuring the height and diameter of planted white pine. These dead branches should be pruned so that the tree will produce lumber free of knots which are caused by the branches.

First. Scale 500 to 1000 trees, using the log scale in common use in the region. Volume tables based on different log scales will show different results, so it is generally better to use the log rule favored by the local lumbermen unless there is good reason for changing.

Second. Group the trees by diameters and classified heights, *i.e.* keep record of all of the 6″, 40′ and all 7″, 40′ trees together, etc.

Third. Plot the contents of the trees. Volume on diameter in height classes, *i.e.* make a separate curve for the 4′ trees as well as for the 45, 50, and 55′ trees, etc.

Fourth. As the values that are read from this curve may increase irregularly, they are plotted again; volume on heights in diameter classes. The final values may be read from these curves and will ordinarily increase from size to size in a uniform manner.

Use. In computing the contents of a forest, following a valuation survey, volume tables are practically indispensable.

The tally sheet of the estimator will give the number of trees for each species and diameter and it is then a very simple matter to multiply the number of 10-inch spruce trees, for instance, by the value given in the volume table for a 10-inch tree of that species. The computations are comparatively short and the results much more accurate than those obtained by using a rule of thumb or from ocular estimates. If the table used is based on classified heights, a curve, plotted height on diameter, must first be drawn to give the average heights for trees of different diameters, in order that the proper values in the tables may be used.

Practically all systematic timber estimating is based on volume tables, and by their use a well-trained forester can go into a new region and compete successfully with local woodsmen whose methods of estimating are based almost entirely on local experience.

Cruising

Cruising is the woodman's term for estimating standing timber. It is rarely an actual measurement of the entire timbered area; a portion is generally measured and this fraction is taken as typical of the whole. The estimating systems may be classified as follows:

First. Ocular. sight
Second. Systematic. systematic

1. *Ocular.* The practice of estimating timber by eye is extremely primitive and is the first method that is used in any virgin country. It is an extremely rough method and its accuracy depends entirely upon the care and experience of the estimator. In the past, ocular estimates served very well because generally a highly conservative estimate was made and due allowance for defects provided for, but with the increase of stumpage values a more accurate valuation must be obtained and, consequently, the day of ocular estimates, on a large scale, is passing.

Ocular estimates were either absolute guesses or else a rough count was made of the trees and sample trees selected. With an experienced cruiser, good results may be obtained in this way, but the same cruiser outside his own type of forest would be apt likely to get inaccurate results, as his experience would be of no avail.

2. *Systematic Methods.* Under present economic conditions and with the need for accurate estimates of volume, growth, and yields, more than a mere guess is needed. For this reason actual measurement of a definite portion of the forest is fast replacing the rough estimate based largely on local experience.

Systematic cruising is done by measuring trees on a strip or by selecting sample plots which are typical of the forest as a whole. In the strip method a compass line is run across the tract to be estimated and all the trees on a strip of a certain width are measured. When the opposite side of the tract is reached, an offset is made, the length of which depends on the percentage to be covered, and then a line is run back across the tract. By crossing the forest repeatedly, from 2½ to 25% of the forest may be measured and an accurate idea of the condition of the topography of the tract, the timber, and the lumbering possibilities may be obtained.

The instruments used in cruising are compass, chain, calipers to measure the diameters, and a hypsometer to ascertain the heights. Under certain circumstances distances may be measured by pacing and heights estimated by eye. A party of four or five men is the ordinary crew, and the duties are as follows: The compass man runs the course, takes notes on the topography, drainage, type of forest, records the distance to roads, streams, etc., and keeps a rough sketch map during the survey. The leader of the party generally acts as tally man and records the measurement of the trees (a separate record is kept of the trees as obtained by the caliper men for each acre or type). Two men caliper the trees 4½′ from the ground and, if a fifth man is available, he assists the tally man or the compass man and meanwhile gathers data on heights, types, condition, etc.

The strips should always be run up and down the main slopes in order to get a true average of the stand. All roads, streams, and ridges should be noted and all data which will have a bearing on lumbering and silvicultural methods of management should be recorded. The ordinary valuation survey consists in measuring the trees on a strip 1 chain, or 66 feet wide, each caliper man covering a distance of 33′ out from the compass man's line. In open timber, like ponderosa or southern yellow pine, a strip 10 rods wide may be covered; but under these circumstances all trees on the strip are counted rather than measured, and every fifth tree is tallied for contents.

The distance covered by an estimating crew depends largely upon the topography, type, and methods of getting diameters, and lower diameter limit. In a dense spruce forest of Maine and northern New York, a crew can make 2½ miles a day with diligence. In ordinary hilly country, with timber of ordinary density, from 3 to 4 miles a day is considered a good day's work; and in very open country, with sparsely timbered areas, 5 or 6 miles of line may be run in a day.

In locating sample plots, average acres may be laid off according to one of two methods. The plots are located either arbitrarily in the different types composing the forest or they may be located on a line across the tract, at fixed distances apart. The plots may be either round or square, accurately measured or approximated. All the trees may be calipered or the number of trees on a given plot may be counted, an average tree selected and the contents obtained by a rule of thumb. The best rule of thumb in practical use is the one used by Ward in connection with his sample plot method. His method consists in counting all the trees on a plot with 118′ radius (one acre), and selecting an average tree by eye. Its merchantable length is estimated in terms of 16-foot logs and the diameter inside the bark at the top and bottom of the stick to be used is estimated. The average diameter inside the bark is then obtained and the contents of the trees computed as follows:

$$(\text{Mean. diam.}^2 - 60)\ .8 = \text{Contents of average 16-foot log in b. f.}$$

Multiplying the number of logs in a tree by this figure will give the contents of that tree. With this figure as an average, the contents of the sample acre may be obtained by multiplying by the number of trees standing upon it.

Determination of Contents of Trees

For ascertaining the contents of trees in board or cubic feet, either for commercial or scientific purposes, a quick method is desirable. In logging work this is very easily obtained by scaling each log by means of a scale rule which immediately gives the contents in board feet. In ascertaining the cubic contents of a tree it is necessary to use one of several methods. The customary way is to multiply the average of the basal areas of both ends of the log in square feet by the length of the log in feet. This will give the volume in cubic feet.

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feet.

Growth Studies. Sometimes it is desired to know not only the present contents of the tree but the contents ten years ago, twenty years ago, etc. Under these circumstances a stem analysis is made. A complete or tree analysis will require the following measurements: diameter breast high outside the bark; height of stump; length of each section; diameter in and outside the bark at each cross-section; diameter growth at each section; age and width of sapwood; total age of tree; total, clear, and merchantable length.

In making stem analyses only sound trees should be selected, as any inferior trees may lead to erroneous conclusions. Under ordinary circumstances the easiest way is to follow the fallers on a logging job and measure the logs which they cut. Crosscuts should be made with a saw and should be at right angles to the axis of the tree. The diameter growth of each section is studied by counting the annual rings, the character of investigation determining whether the count is started at the center or the outside. If the average diameter growth is the object, count the rings outward, beginning at the pith. When volume growth is wanted, count the rings inward and measure outward by decades; that is, by making a mark at each tenth ring and measuring the distance from decade to decade, the diameter of the section ten, twenty, or thirty years ago can readily be computed. From this the volume of the log may be computed by decades.

The number of rings at each cross-section indicates the age of that section and, by computing the volume of the tree, considering both height and diameter, the contents may be easily ascertained. Such an analysis is indispensable in an accurate growth study.

Where a record of growth is not necessary and a statement of present dimensions will suffice, taper tables may be used in place of stem analysis. Under these conditions the dimensions of the trees are recorded at certain fixed distances above the stump, so that by means of a log rule the contents of the total tree may be worked up, but without, of course, considering age or growth. Taper tables will be sufficient for constructing or amending volume tables, but since age is not considered, *i.e.* no rings are counted, they are of no use in the study of growth.

FIG. 92.—Forester determining the rate of growth by use of the Swedish increment borer in a mature shortleaf pine stand in Arkansas.

By growth is meant the increase of a tree in size. Height, diameter, area, and volume growth cover the phases of a tree's increase. Of these volume growth is the most important, considered from an economic standpoint.

The methods of studying diameter growth and volume growth were touched upon in connection with stem analysis, but the study of the growth of a single tree is of minor importance in comparison with the volume growth of stands.

As previously described, the volume growth, or increment, of a single tree may be ascertained by computing its contents and comparing them with the contents of the tree ten, twenty, and thirty years ago; but this method involves a maximum amount of computation and is chiefly valuable in scientific investigation.

For practical purposes the increment of forests is generally calculated or predicted in one of two ways. The *mean annual increment method* is based on the assumption that a forest will grow during the next five years at the rate that it has maintained up to the present time. For example, a pine forest at forty years contains 24 cords of wood per acre; the mean annual growth, therefore, is .6 cord per acre per year. According to this method the increase during the next ten years would be at the same rate, and at fifty the stand should yield 30 cords per acre. The accuracy of this method depends entirely on whether the growth rate is increasing or decreasing.

The growth percentage method is also used in somewhat the same way, and its use is largely confined to mature forests whose height growth has practically ceased and the forms of whose component trees remain unchanged. Schneider, a German forester, put forward a formula for determining the growth percentage depending on the rapidity of the radial growth.

A sample plot is measured, as the first step in this method, and the average tree or trees selected. They are then chopped or bored breast high to ascertain the number of rings in the last inch of radius at the point where it is measured. An instrument, called an increment borer, consisting of a hollow auger, is commonly used to extract a core whose rings can be counted.

The growth percentage is then found according to the formula.

$$\text{growth } \% = \frac{400}{nD},$$

where D equals the diameter $4\frac{1}{2}'$ from the ground and n equals the number of rings in the last inch of radius at that point. If the stand runs 8000 b. f. per acre and the growth percentage is found to be 3, then the forest is increasing at the rate of 240 b. f. per year and in five years the stand would run 9200 b. f. per acre.

Both the above methods give results which may serve the purpose where only approximate figures are needed. For scientific purposes more accurate methods must be used.

Yields

To predict the contents of a forest at specified ages a yield table is used. This is a tabular statement of the contents per acre of a forest growing on a specified site and handled in a certain manner. The best tables contain yields for each of the three qualities of forest soil, and in addition, state whether the forest is pure or mixed, thinned or unthinned.

Yield tables, to give satisfactory results, should be used only in the region where they are constructed. Even in Germany, with its limited area in comparison with the United States, " local " yield tables are preferred to " general " tables.

Two kinds of tables are recognized.

1. Normal.
2. Empirical.

A normal yield table shows the yields per acre for fully stocked stands. It gives the average maximum yield actually obtainable, provided the stand has not been injured by fire, wind, insects, etc.

Empirical tables show the average stand per acre for the whole forest area regardless of whether it is fully stocked. They consist merely of a table of average contents and, compared with the normal tables, are indefinite and inexact.

The selection of plots for making tables requires considerable skill and the general tendency is to pick stands which are understocked. Complete measurements of the stand are taken and the contents per acre are plotted on cross-section paper — volume on age.

Use of Yield Tables. Yield tables are extremely valuable in determining the value of second-growth timber, in predicting future yields, and as a check in estimating the contents of stands. With the increasing importance of exact information concerning forest management, yield tables are becoming more necessary, and the next decade will no doubt see the number of American yield tables greatly increased.

CHAPTER XI

HARVESTING (LOGGING AND MANUFACTURING) THE LUMBER PRODUCT

History

From the earliest Colonial times lumbering, the first American industry, has been also one of the most typical and most important industries. It vied with the fur trade in the first exports to Europe. Sawmills were early established at Jamestown, Virginia; they were driven by the wind on Manhattan Island in 1624 as they are today in Holland. There was a large and flourishing sawmill at Berwick, Maine, in 1631. Lumbering was first done near the settlements; then the lumbering areas were extended up the rivers along the Atlantic seaboard. There were river driving and rafting on the Connecticut, Hudson, Delaware, Susquehanna, Potomac, and James Rivers. Early sawmills produced from 1000 to 6000 b. f. per day.

Maine developed early as the center of the lumber industry. Maine held this position for two centuries, until the center of the lumber industry shifted to New York. New York was the center of the industry in 1850, and Albany was a great lumber market for the entire nation. The lumber industry reached its ascendancy in Pennsylvania in 1860, and Williamsport became a great manufacturing and distributing center. Then the center quickly shifted to Michigan, where the peak of lumber production was reached in 1892. Until this time white pine, the most useful tree found in American forests, was the predominant species. The white pine of the Lake States and the southern pine of the South were used for the great building program during the expansion and up-building of the fertile plains and prairies of the Middle West.

The peak production of southern pine came in 1907, concurrently with the peak of national production of 46 billion b. f.

of lumber that year. Then the center of the industry shifted to the Pacific Coast, where the peak production of Douglas fir was reached in 1926.

Great changes and improvements also characterized the development and the growth of the lumber industry. Oxen were used for hauling in Colonial times; horses and mules were used later. The big timber of the Pacific Coast had to be handled by a system of steel cables and power logging. Railroads, in the Civil War period, met the demand for logs for the big sawmills. Finally, the motor truck and tractor have revolutionized methods of lumbering.

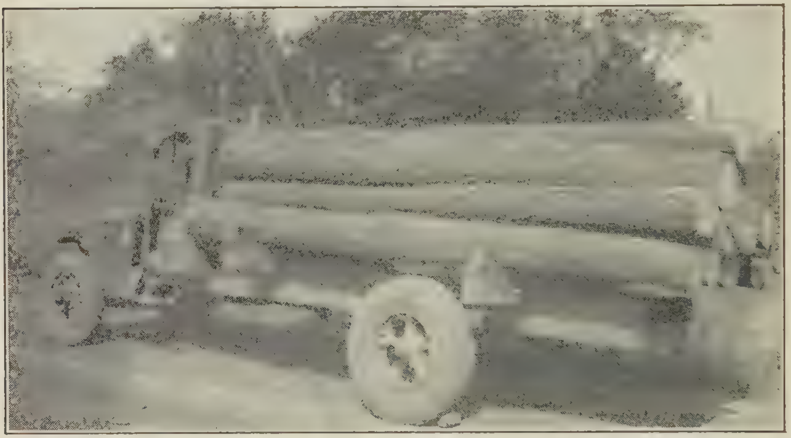

FIG. 93.—Motor trucks are commonly used to haul logs from one to sixty miles or more to the sawmills. They have superseded the log wagon and in many cases the logging railroad, chutes, flumes, winter sled hauling, and even water driving in parts of the country. This is a $2\frac{1}{2}$-ton truck hauling a usual load of about 900 b. f. of green pine logs in Georgia. The truck provides a flexible unit and is widely used by lumber companies to haul logs in the open log market, a few logs being secured from widely scattered farm woodlands and small tracts of timber.

The circular saw, driven by steam, replaced the old waterfall as a source of power. The circular saw was gradually replaced by the band saw, which reduced the saw kerf from $\frac{1}{4}''$ to $\frac{1}{8}''$ or $\frac{3}{16}''$. Great wastage attended the cutting of the forests and manufacturing logs into lumber. The public demanded only clear, wide boards, free of knots or other defects. Lumber frequently sold for $10 to $15 per m. b. f. at the sawmills.

Standing Timber and Stumpage Values

The value of standing timber, known as stumpage, rose with the increasing demands for lumber. Until about 1860, timberlands had little, if any, speculative value. Stumpage was then priced at about $1.00 per acre for magnificent virgin, old cork white pine in Michigan. An acre often contained from 20,000 to 30,000 b. f. By 1880, white pine was worth $3.00 per m. b. f. Then the price gradually rose to $10—$15 for the best stands.

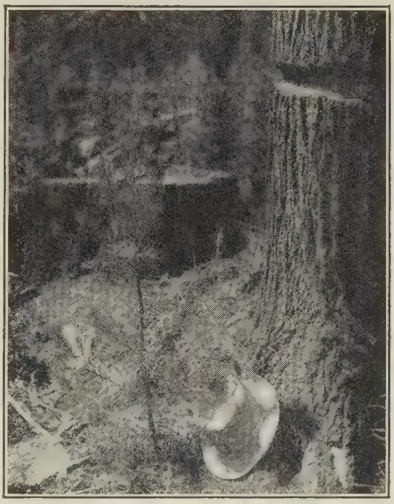

FIG. 94.—White pine seedling carefully protected in felling and skidding on a National Forest timber sale. Note the low white pine stump and girdled trunk of worthless hemlock in northern Idaho. Animal skidding is least and power skidding most destructive to young growth.

With the diminution of southern pine production beginning in 1916, many operators moved to the West Coast. Often the demand for stumpage inflated values so that the cost of production in recent years has exceeded the value of the product. Carrying charges such as interest, protection, taxes, etc., proved to be exceedingly burdensome and much timber had to be liquidated, resulting in losses instead of profits and consequent economic demoralization in the lumber industry of the Pacific Northwest.

The value of any stumpage depends upon its species, quality, location, logging costs, and demands on the market. There is still some timber, such as the western true firs, western hemlock in the Inland Empire, and western larch which may have no stumpage value because of their remoteness and inaccessibility, poor condition, or lack of any demand on the market.

Examples of approximate stumpage values at present are \$1.50 to \$4.00 per m. b. f. for Douglas fir; \$3.00 to \$5.00 for southern pine. These are the most commonly used types for lumber and generally represent very low-value stumpage. Other representative values are \$2.00 to \$3.50 per m. b. f. for ponderosa pine; \$5.00 to \$10.00 for virgin longleaf pine; \$4.00 to \$8.00 for western white pine; \$3.00 to \$6.00 for sugar pine; \$5.00 to \$10.00 for white oak; \$5.00 to \$12.00 for yellow poplar; \$6.00 to \$10.00 for ash and cherry; \$5.00 to \$10.00 for eastern white pine; \$1.00 for western hemlock; \$2.00 to \$5.00 for eastern hemlock; \$4.00 to \$8.00 for yellow birch and sugar maple; \$5.00 to \$12.00 for cypress; \$4.00 to \$7.00 for eastern spruce, and \$3.00 to \$5.00 for western spruce. All standing timber of these species is not worth as much as these representative values; but, rarely, some timber values will exceed these prices. Small, poorly shaped, decayed, and crooked trees of all of theses species would be worth much less than the values listed above.

The United States Forest Service and several state forestry organizations sell stumpage or standing timber to private operators under timber sale contracts to insure the reproduction and sustained yield of the forests. It is believed that the private operators with proper planning can cut timber on private forests to better advantage, that is, more efficiently and with the best forestry practices, than can the governmental agencies themselves. Private business has demonstrated that it can operate more efficiently than can men in the public employ. The supervision and inspection of timber sales, however, should be left in the hands of the public agencies on public properties.

Methods of Logging

Logging is preeminently a problem in transportation — felling trees, cutting the stem into saw logs, and skidding them to assembling points known as landings. Then the logs are loaded on some transportation device or log haul and sent to the mill. There are three methods of skidding, namely by: (1) animals — that is, horses, mules, or oxen; (2) by tractors, which have come into wide use in all parts of the country since the World War; and (3) by power skidding, widely used in the big timber of the Pacific slope. Oxen have been entirely replaced in the woods by horses and tractors. Mules are still used for hauling to a considerable extent in the South. Altogether animals have been largely replaced by tractors, which vary from 15 h.p. to 90 h.p. or more. Tractors are a most valuable machine because they are used in building roads, plowing furrows for reforestation, cutting out fire lines, hauling in supplies, skidding logs, and in many other ways. There are several thousand tractors in use in the woods for logging operations. There are more in use east of the Rocky Mountains than west. They have proved to be an economic and successful method of skidding. They do less damage to reproduction, young growth, and the residual

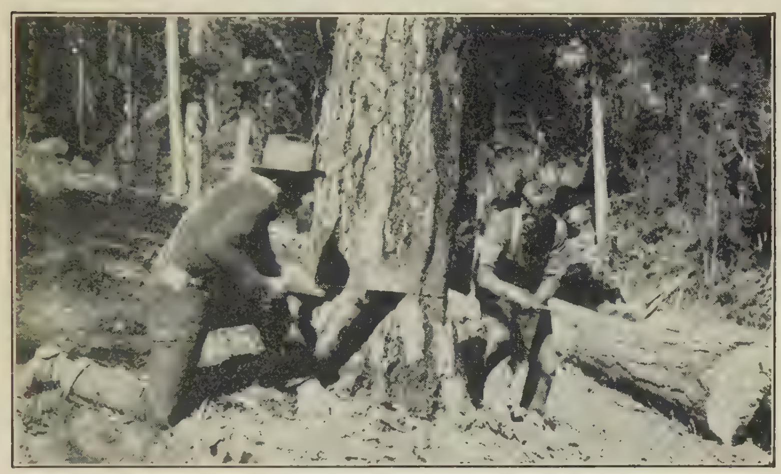

FIG. 95.—Two men felling a tree by the use of the cross-cut saw. The tree is first notched and then sawed immediately above the root swell. Stumps are being cut with much less loss in good timber than formerly.

stand than power skidding, and very little more than horses. They are required on many National Forest timber sales in California where they have replaced power skidding both for reasons of good forestry practice as well as for economy. Power skidding is no longer used in the East and Lake States, where it was once occasionally used. It is being rapidly replaced in the South by the tractor and motor truck. Even on the West Coast it is being replaced by the tractor and motor truck, but to move the enormously large and heavy logs of the West Coast, power skidding will continue to be used as long as the big virgin timber is available.

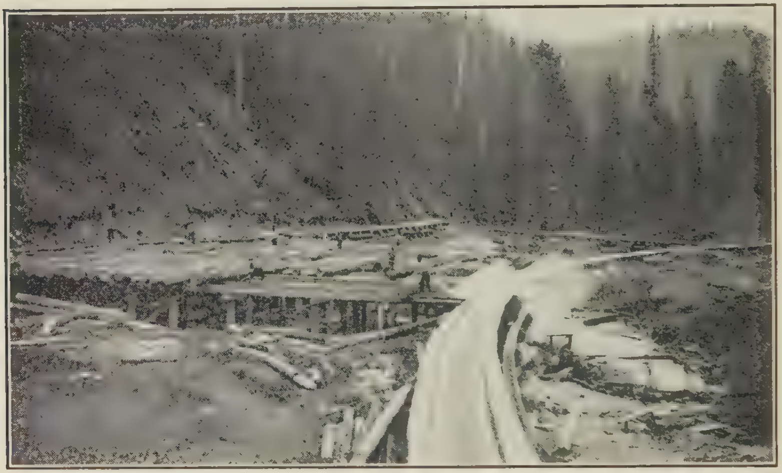

FIG. 96.—Rolling logs from the landing at the terminus of a chute on the left into the flume on the right.

Major Log Transportation

Many methods have been devised to suit the various climatic, labor, topographic, and timber conditions. Logs are often hauled from 5 to 100 miles or more to the great sawmills. In the early days, until the timber adjacent to the streams was cut, stream driving and rafting were used. Then logs had to be hauled considerable distances. With the demand for an increased flow of logs to supply the big sawmills, railroads replaced stream driving and rafting. In the North, the Northeast, and eastern Canada, sleds were used in winter for hauling logs to the driving streams and to the loading points of railroads. In the Inland Empire chutes and flumes were developed, especially in Idaho, and generally for short distances in steep topography. One flume in California, 55 miles long, took lumber from a mill in the Sierra Mountains down to the loading point at Madera in the San Joaquin Valley. Rafting, formerly used throughout the East and South, is still employed on all the larger streams and estuaries of the north Pacific Coast, British Columbia, and southern Alaska. Rafting is also widely employed on the Great Lakes and along the St. Lawrence River and its tributaries. Railroads still convey the largest volume of logs to the sawmill. There are over 500 separate logging railroads in the state of Washington alone.

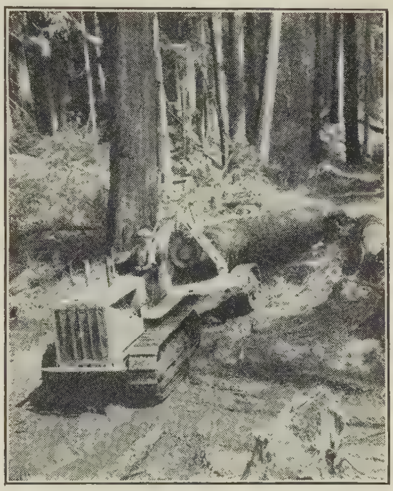

Fig. 97.—A Caterpillar Diesel 50, with Carco arch and drum, or a 75-h. p. gasoline tractor average 100,000′ of logs to the landing per 8 hours on an average skidding distance of 1000′.

There are many interesting stories of remarkable feats performed in the old lumbering days. Tales of Paul Bunyan and his superhuman exploits in the Michigan and Wisconsin woods have been the basis of some of the best of American folk-lore. Every forester knows of the remarkable feats performed by Paul and Babe, his big blue ox. A splendid poem by Douglas Mallock entitled " The Round River Drive " gives the atmosphere of woods life in the busiest logging times of the Lake states. It is often recited at meetings of foresters and lumbermen.

Selective Logging

Selective logging is the partial cutting of the forest to flexible diameter limits to increase present profits and to perpetuate and improve the forest for the future. Selective logging embodies the very essence of forestry principles as applied to virgin or second-growth merchantable timber. It satisfies both present and future requirements in forest management. It is constructive, as contrasted with former destructive methods of forest exploitation.

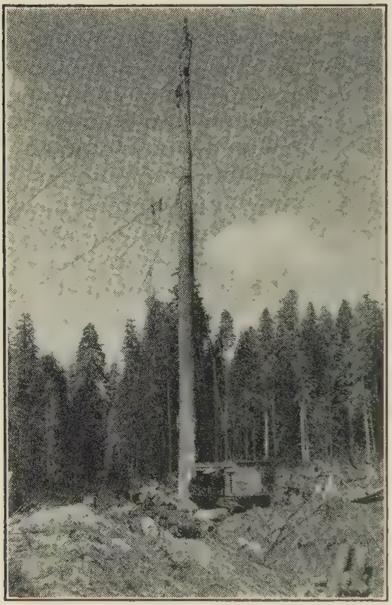

FIG. 98.—In the Pacific Northwest power skidding is used to bring in the logs of great size and length. There is now a gradual change toward the use of more tractors and trucks in getting out the logs. This shows a typical high-lead yarding system and duplex loading with an electric donkey engine near Snoqualmie Falls, Washington. Cables are run out into the woods, generally from 1000′ to 2000′ or more. The headspar tree shown in this picture is supported by a number of guy ropes.

American timber cutting and applied silviculture have developed more progressively and actively in selective logging than in any other way. It is apparent that American economic and silvicultural conditions lend themselves to selective logging better than to some of the conventional European methods which have been described.

Only those trees are cut which will yield an immediate cash return. Formerly there was little if any scientific determination of what size trees would turn out profitably when logged, manufactured, graded and seasoned. The matter of selectivity may apply to individual trees, groups or areas. It is a combined silvicultural and utilization measure, although its objectives are primarily for utilization. On national and other public forests, selectivity serves both purposes. It has been unintentionally practiced in a crude and unscientific manner for many years on farmers' woodlots throughout the East and on many private operations. It recognizes the established fact that logging costs per thousand board feet increase with decreasing tree sizes. Conversely, the larger the tree the lower the cost of logging per thousand board feet. Lumbermen have heretofore roughly estimated the size of trees to be cut. Often they have " skinned " the areas, believing that cutting all trees, even to trees of small size, would result profitably. There is a distinct but variable relation between tree sizes and profits. When lumber prices are relatively high and attractive, smaller trees may be profitably logged. Too frequently, however, trees are cut when at the most rapid period of growth and when lumber markets are glutted with timber cut from trees below commercial sizes, especially in the South, Lake States, and the Northeast.

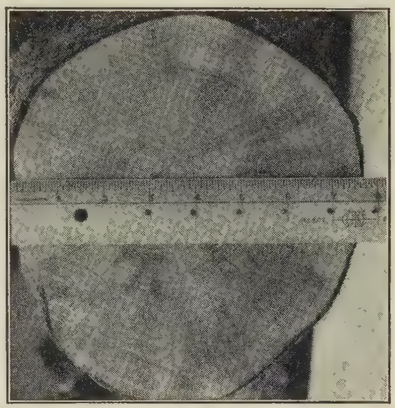

FIG. 99.—Cross-section of lodgepole pine showing rapid growth after selective logging. When the crown of this tree was given more light and room to expand, the growth rate quickly increased as shown in the width of the annual rings. After release, it required only 2 to 4 years to grow an inch in diameter, whereas it had required from 4 to 8 years to grow an inch in diameter before.

Several studies have recently been made by Zon, Garver, Gibbons, Brundage, and others to determine the size of trees which may be profitably logged. Selective logging is being introduced in several forest regions. Test logging plots have been established in order to ascertain facts. Selective logging has made real progress on the Sawyer-Goodman tract in Wisconsin and on plots of the Camp Manufacturing Company in eastern Virginia, the Crosset Company in Arkansas, the Weyerhaeuser Companies in Idaho and the Northwest, and several companies in California, Washington, Oregon, and Idaho.

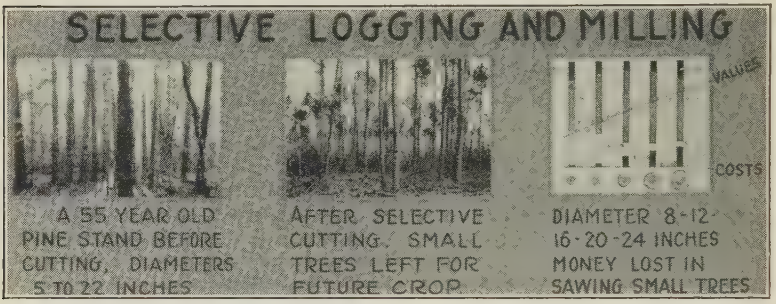
SELECTIVE LOGGING AND MILLING
VALUES
COSTS
A 55 YEAR OLD PINE STAND BEFORE CUTTING, DIAMETERS 5 TO 22 INCHES
AFTER SELECTIVE CUTTING. SMALL TREES LEFT FOR FUTURE CROP
DIAMETER 8-12 16-20-24 INCHES MONEY LOST IN SAWING SMALL TREES

FIG. 100.—Illustrating several phases of selective logging and especially the increased value secured from large-sized trees; and, conversely, how logging costs decrease with increasing size of trees felled in the woods.

Generally, foresters mark individual trees to be cut. The sizes marked for cutting may vary with the species and with local conditions, but studies have indicated that the best sizes for cutting are 34″, or more d.b.h., in Douglas fir; 40″ in sugar pine; 20″ in ponderosa pine in western Montana; 18″ in shortleaf pine in Arkansas, loblolly pine in the Southeast, red oak in North Carolina, and beech, birch, maple, and hemlock in the Lake States.

The advantages of selective logging are:

1. Only trees yielding a definite profit are cut. Higher grades of lumber which command the best market prices are obtained because only the largest and best trees are removed.

2. Felling, bucking, swamping, and skidding costs are reduced. Other logging costs, as hauling, are also reduced.

3. The condition of the forest is improved because the favored species are left in the stand and better-quality reproduction is assured for the future.

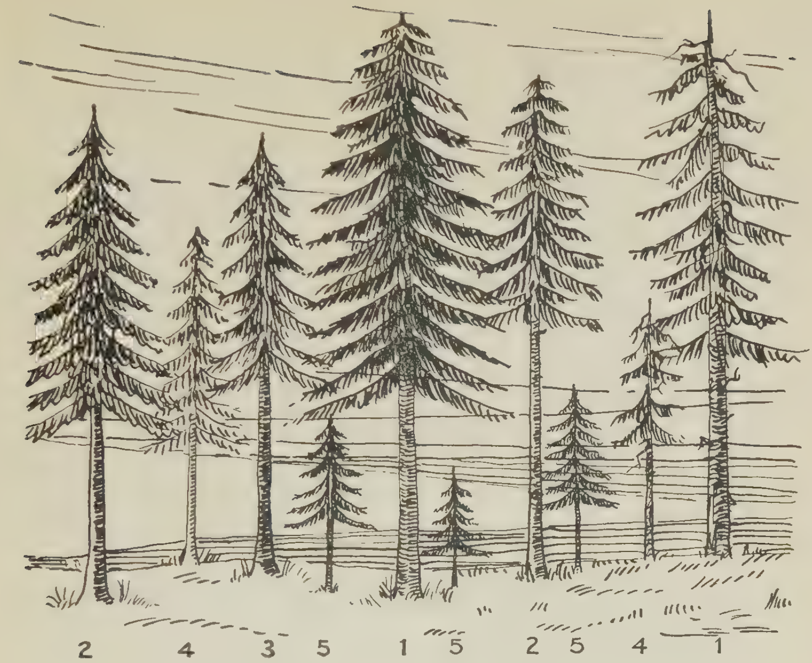

FIG. 101.—Tree classification for selective logging. Much skill and experience are required in marking trees to be left in any stand for future growth and those to be taken in the felling area. This figure illustrates some common forms of trees found in a coniferous stand. The same general principles apply to hardwood stands. The felling area may include a few acres or up to 1000 acres, or more. Trees of one class may cover one or several acres, or they may be interspersed in varying age conditions, size, etc., throughout the felling area.

Those marked 1 are mature or over-mature with spike tops. Growth has slowed down or stopped, they are susceptible to insect or disease attack, and they have passed their prime. In some cases they are over-mature and may be partially decayed and the cull in scaling the logs from them may be very heavy. Crown space takes up entirely too much room and should be left for the younger, thrifty growing trees.

Those marked 2 are thrifty, growing vigorously, are good producers of healthy seed; some are not large enough to produce high lumber values and should be left for subsequent cutting. They are at present of medium or low lumber value and are relatively wind-firm and free from insect attack. They are laying on a good volume increment so that both quantity and quality values are increasing. Number 3 is a co-dominant tree, which is not growing as rapidly as the Number 2 trees, but needs release of its crown cover by thinning for increased growth. Number 4 trees are too small for cutting; the one on the left is making fair growth and will increase its rate if released from crown competition. It is a poor seed-bearer. The Number 4 tree on the right has been over-shaded, is laying on practically no growth and is in poor condition and, if merchantable for any purpose, may be cut and the growing space left for more valuable trees or for reproduction or planted trees to occupy the soil and ground space. Number 5 trees are advance reproduction in the sapling or small pole stages of development. Cuttings should be made to give their crowns more space for development and increased growth. Care must be exercised in logging so the trees are not damaged during felling and skidding operations.

4. Young timber on the area is left in good growing condition, thus substantially putting the forest on a sustained yield basis.

5. Better fire protection is assured by leaving a smaller amount of slash and débris.

6. Selective logging prolongs the life of lumber operations, thus contributing to greater stability and permanence of sawmills, which in turn make for employment and community life.

Among the disadvantages of selective logging may be cited the following:

1. For some forms of small products such as cross ties, pulpwood, chemical or acid wood, fuelwood, posts, small poles, and piling, there is no marked advantage in cutting only the larger trees.

2. Greater skill must be exercised in removing the timber. Supervision, marking, etc., must be done by skilled foresters; and the area must be carefully cruised, mapped, and studied before the plan is made effective.

3. Immature timber must be protected and taxes continually paid upon it. Some local assessors may not reduce taxes proportionately with the removal of the best standing timber so that the financial accumulation may be greater than the volume growth.

4. It is not especially applicable to large, even-aged, or intolerant forests where a considerable number of the trees are of large sizes and grow so densely that the small trees cannot be protected in the felling process.

5. It cannot be practiced on logging areas cut under enforced liquidation of standing timber assets. This is a powerful factor in the Pacific Northwest region where the burdens of interest and taxes have intensified exploitation without any thought of the future.

The above disadvantages, however, are not universal and are not entirely unsurmountable even in some of the regions where they may apply. Selective logging is probably practiced more than any other form of logging in our National Forests, especially in the pine forests of California, Oregon, and Idaho.

The Southern Forest Experiment Station has made studies of the costs of forest inventories and marking in connection with selective logging and sustained yield management on private properties. The costs of a detailed inventory, including a 100% cruise of trees 13″ d.b.h. and over, and marking the trees to be cut on about 3000 acres of southern pine were $0.103 per m. b. f. of timber marked to be cut, or $0.54 per m. b. f. of the total stand. There were 21 million b. f., log scale, or 7000′ per acre, on the tract. Trees for cutting were marked with white paint on four sides.

Selective logging may be applied to second growth as well as to virgin timber. Second-growth stands ordinarily do not produce as much clear and high grade lumber as primeval stands. However, Reynolds of the Southern Forest Experiment Station has shown that second-growth shortleaf and loblolly pine does produce high quality lumber if larger tree diameters are taken. On a typical 280 acre tract of second growth 50% of the timber volume was cut, taking trees 17″ and over in diameter. A few

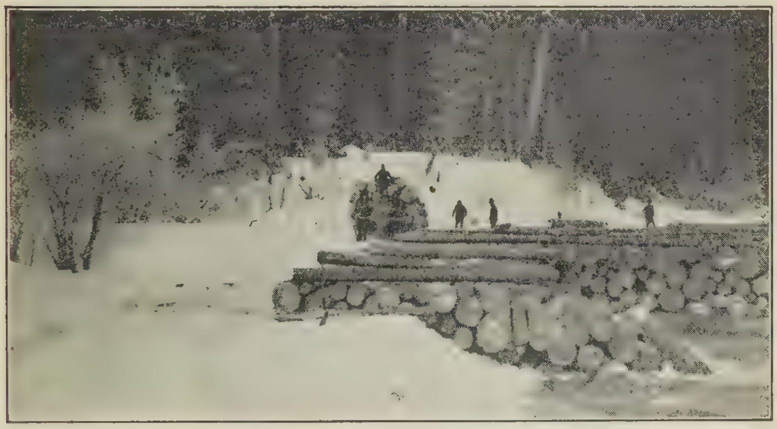

Fig. 102.—Hauling in logs on two-sled to the landing where the logs are stored until the annual spring drive.

crooked and defective trees from 13″ to 17″ in diameter were also taken. A mill scale study showed that 20% of all lumber was of first grade quality, known as *B* and better grade, and 30% was of second quality, known as number one common grade. These are excellent results, because a lumber company operating in the same region in virgin timber cut 24% of *B* and better and 26% of number one common grade. Therefore, the southern pineries are likely to continue as important producers of high-grade lumber rather than the low-value and poorer-grade material which is generally associated with our second-growth stands. Thus, selective logging as the cornerstone of successful forest management seems likely to be the crux of future forestry in the South. This is a recent development which augurs well for the future of our southern forests.

J. W. Girard of the Forest Service has pointed out that in selective logging in the South, second-growth loblolly pine trees of 12″ diameter will increase to 20″ in 20 to 30 years. The average 12″ two-log tree produces about 80 b. f., whereas a 20″ three-log tree will produce about 400 b. f. Thus, on an average, of 25 years additional growth gives the tree five times as much volume.

Lumber Manufacture

The demand for lumber has been phenomenal during the expansion periods, conspicuously so in the development of the Middle West. From the early water-driven mill came the steam-driven circular mill. Then the band saw was introduced in 1890, resulting in enormous saving in sawdust by a narrower kerf and much better sawn lumber. Sawmills at first produced only 5000 to 10,000 b. f. per day. With improvement in mechanical facilities and by multiplicity of machinery, production rose from 10,000 b. f. to 50,000 or 100,000 b. f. per day. There are a few sawmills which in double shifts now produce about one million b. f. per day. Longview, Washington, is the great lumber capital of the world, with the two big sawmills of the Weyerhaeuser Company and the Long-Bell Company. Great centers of lumber production developed in the South, at Bogulusa, Louisiana, Laurel, Mississippi, Crossett, Arkansas, Chapman, Alabama, Foley and Shamrock, Florida, and many other centers. Seattle, Tacoma, Everett, Bellingham, Vernonia, Aberdeen, Hoquiam, Bend, and Lewiston are great lumber centers in the Northwest.

When logs come in from the woods they are generally stored in a log pond until needed at the mill. Because hardwoods do not float well, log ponds are seldom used with them. Some log ponds, located along rivers, streams, or in tidewater, are used to store several million board feet. In other places artificial ponds must be provided. In winter "hot ponds" are provided

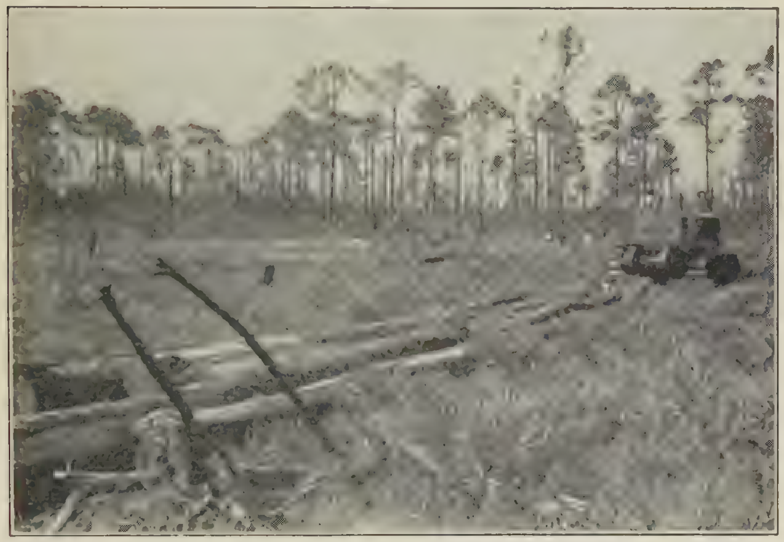

Fig. 108.—A Caterpillar Diesel 50 h. p. tractor skidding logs in longleaf yellow pine near Perry, Florida. It costs $150 per month less to operate this type of tractor than the 60 h. p. gasoline tractor and approximately the same quantity of logs is delivered to the railroad. These tractors have replaced overhead skidders, and are much less destructive to reproduction and young standing timber. Tractors may also be used in plowing furrows for fire lanes as well as for planting trees and for road construction.

to keep the water from freezing by using the exhaust steam from the sawmills.

The logs are usually taken up a log slip, known also as a jack ladder or jacker chain, to the second floor of the sawmill, which is equipped with mechanical and labor-saving devices to move the log and its products through the saw, edgers, trimmers, etc., to the sorting table where the lumber is sorted and graded preparatory to piling. There are several successive steps followed to convert a saw log into lumber at a large band mill. (1) A log is moved from the log pond or storage yard up the jack ladder. (2) The log is cross-cut to desired log length. (3) The log is rolled down the log deck, where it remains until needed for sawing. The log stop and loader holds the logs back and moves them forward as needed. (4) On the saw carriage the log is loaded against head blocks and moved over steel rails through the saw. The carriage is manned by 2, 4, or more men who on signal from the sawyer see that the log is placed in such position that the desired widths of boards or timbers are cut. A steam-driven instrument, known as a " nigger " or log loader, is used to move the log from the deck to the carriage. (5) The band, or circular saw, controlled by the sawyer, makes the cuts as shown in the illustration. (6) The lumber is passed to the edgerman who directs it through the edger saws, which make parallel saw cuts 8″, 10″, 12″, etc., in width and remove the bark or other defects. (7) The lumber then goes to the trimmer which cuts the boards into exact lengths, 10′, 12′, 16′, 20′, or removes knots or other defects in order to get the best clear boards and therefore advance the grade as much as possible. (8) After trimming, the lumber is moved to the sorting and grading table where an inspector marks each piece with a sign denoting its grade. Then all boards of the same length, thickness, species, and grade are piled separately for seasoning. This requires a large number of piles because there may be six or more grades, in each species, the boards may be from 6′ to 16′ long and in thickness from 1″ to 3″ or more in quarter-inch variations, that is, 1″, 1¼″, 1½″, 1¾″, 2″, etc.

Timbers (6″ × 6″ and larger) are not edged nor trimmed but go directly on live rolls to the docks to await loading on railway cars. From the time logs enter the mill until conversion into boards and piling, in the yard, the lumber is moved by live and dead rolls, endless chains, conveyors, and "moving platforms" — labor-saving devices. The kicker, log stop, and loader, "nigger," carriage, rolls, chains, and conveyors motivated by steam or electricity are mechanical devices designed for speed in transporting logs and lumber through the mill.

Small Circular, Band, and Swedish Gang Mills

Within recent years notable changes have taken place in the manufacture of lumber. The principal ones may be summarized as follows:

1. Small circular sawmills. Probably three-fourths of all the lumber produced east of the Rocky Mountains comes now from small circular sawmills cutting from 3000 to 10,000 b. f. per day. With the cutting of the virgin and larger timber areas, the smaller units lend themselves best for conversion into lumber by means of these small mills, which may be set up at a cost of $1000 to $3000, or more, and can be operated by two to eight men, or more.

Most of these mills are inefficient, however, as they produce poorly sawed lumber and follow very wasteful methods, both in the woods and at the sawmills. A saw kerf of $\frac{1}{4}$″, instead of $\frac{1}{8}$″ to $\frac{3}{16}$″ as in the band-saw mill described above, is used and the boards are of very irregular thickness and widths. Many are farmer-owned mills. In the South, one owner may operate or control from 5 to 20 mills, from which the lumber is shipped to a concentration plant, where it is properly seasoned, perhaps kiln dried, then planed and shipped to market, to compete with the lumber cut at larger sawmills.

The tendency is to move these small mills less and less, because with improved highways and better trucks, the logs can be moved for distances of 10 to 60 miles, or more. This is cheaper than moving the mills at frequent intervals. Many of them do custom sawing, charging from $6 to $8 per m. b. f.

2. The portable band saw has been recently developed and used in the South. A small-sized band saw is set up on a heavy frame and is capable of being moved, either on railroad cars or on motor trucks, from one location to another. The chief advantage is cutting more true and accurately sawed lumber as well as a narrower kerf, with much lower resultant losses in sawdust. These have been used successfully in Alabama, North Carolina, and other portions of the country.

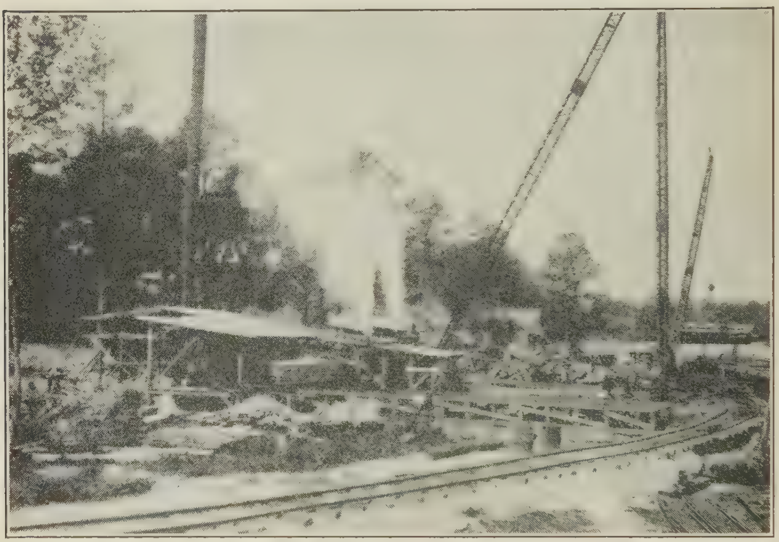

Fig. 104.—Two units of portable band mills mounted on steel flat cars near Jamesville, North Carolina. Two saws feed one edger and one trimmer. The saw kerf is only $\frac{3}{32}$″ compared with a circular saw kerf of $\frac{1}{4}$″ or more, or large band saw kerf of $\frac{1}{8}$″. These mills are portable and can be operated with a small number of men. This represents a new development in lumber manufacture.

3. The Swedish gang saw, as introduced by Oxholm in the Pacific Northwest, cuts small-sized logs into boards of 1″ or 2″ dimension. The logs are fed directly into a series of saws arranged in a frame 1″ apart, or to fit the desired lumber product. Thus, many saw cuts are made synchronously and much

lumber may be produced at a minimum cost. By this method logs may not be turned on the carriage to avoid knots, checks, decay, and other defects, so that it is most adaptable to sound, second-growth, and smaller-sized logs with small tight knots, which are acceptable for boards and dimension for a large part of building construction. This is the type of mill used in Europe to convert logs into lumber and timbers. It is an economical method of sawing because of the small saw kerf and because the entire log is sawed into lumber at one time.

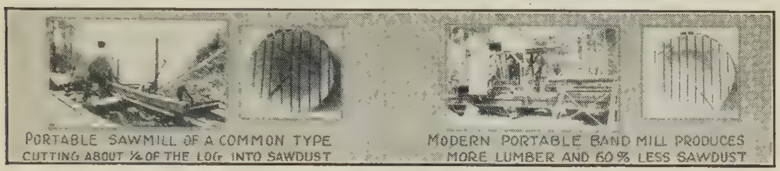
PORTABLE SAWMILL OF A COMMON TYPE
CUTTING ABOUT ¼ OF THE LOG INTO SAWDUST
MODERN PORTABLE BAND MILL PRODUCES
MORE LUMBER AND 60% LESS SAWDUST

FIG. 105.—Illustration of the greater volume of good lumber secured by using portable band mill rather than the usual circular type of small sawmill.

Seasoning and Conditioning

About half the weight of wood consists of water. This water must be largely eliminated before lumber can be properly used. For many years lumber has been largely air seasoned; that is, various pieces are placed in a pile separated by small pieces known as sticker strips so that the air will circulate between the boards and the moisture content will be reduced from about 50% to around 15-20%. This process generally requires from 4 to 6 months, or more, with softwoods and much longer with hardwoods. A quicker but more expensive method is to put the lumber in a dry kiln where artificial heat and humidity are applied to quicken the process of seasoning and moisture elimination. Wood is very hygroscopic, that is, it absorbs and releases moisture very quickly. That is why doors, windows, and particularly bathroom cabinets swell in the summertime and shrink with the winter indoor heat. Some of the modern mills are putting green lumber directly from the sawmill into dry kilns and reducing the moisture content to 6% or 8%. Generally hardwoods must be air seasoned first and then kiln dried before being finally planed or made into furniture, flooring, doors, interior finish, etc.

Lumber Merchandising and Distribution

Much is heard in forestry circles about sustained yield production. This is very necessary and important, but sustained and maintained markets are equally important. The inroads of substitutes have caused a decrease in both total and per capita consumption of lumber. Many men trained in forest schools are assisting in the merchandising and distribution of lumber. College-trained men are needed to develop and improve methods of marketing our lumber product.

At first lumber was consumed near the sawmills. With the removal of the virgin resources of the Northeast and Lake States lumber was produced at greater distances from the important consuming markets. When the centers of lumber production moved to the South and Far West the centers of consumption remained in the North and Northeast. In 1914, the average rail haul for lumber from mill to market was 360 miles; in 1924, 725 miles. Thus the distance was doubled in a decade. Lumber coming to New York usually travels by rail an average distance of 840 miles, to Detroit about 910 miles. The average rail haul from the Northwest to the East is about 2600 miles and via the Panama Canal about 6000 miles.

New York, Chicago, and Los Angeles are the most important lumber-consuming centers. Lumber consumption follows very closely population concentration and industrial activity. The principal lumber-consuming states are New York, California, Illinois, Michigan, and Pennsylvania. The general metropolitan district of New York City normally consumes about 2½ billion b. f. The Chicago district and the Los Angeles district both consume nearly as much lumber as New York. Los Angeles leads the world in the volume of lumber received and handled by water.

Of the immense volume of Douglas fir produced annually, about 13% is used within the local producing territory, 23%

is shipped to California, 34% to the North Atlantic States largely by water movement, and the remainder, 30%, to the Middle West. Since the opening of the Panama Canal the movement of lumber has increased enormously from a few million feet to 2 billion b. f. in 1928. During the economic depression it dropped to below 1 billion b. f. About 70% of all lumber is sold through wholesalers who serve between the manufacturer and the retailers, industrial consumers, and others. Also about 75% of all lumber is sold to the ultimate consumer through retail yards. The United States is the most important country in the production and consumption of lumber and it also is the leading country in the value and volume of export lumber.

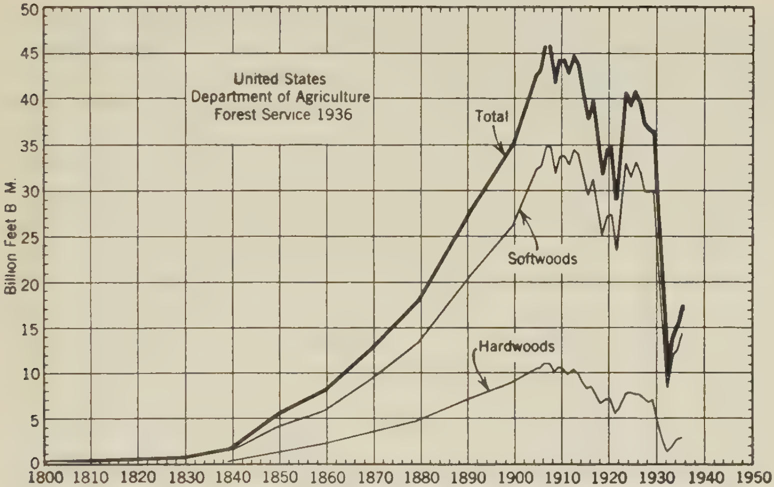

FIG. 106.—Graph illustrating the rapid rise of lumber production culminating at its peak in 1907, when 46,000,000,000 b. f. were produced and then dropping during the economic depression to about 10,000,000,000 b. f. in 1932. As shown in the graph, a large portion of the production is in softwoods.

Lumber Production by Species and Important States

Although lumber is produced from a great many species, Douglas fir comprises about 30%, southern pine about 30%, and ponderosa pine about 12%. These three species make up 72% of all lumber produced. Softwoods make up the big bulk of lumber production. Hardwoods have fallen off from 21% in 1919 to 14% in recent times. The 14 leading species in order of importance are: southern pine, Douglas fir, ponderosa pine, oak, white pine, including both northern and Idaho white pine, hemlock, both eastern and western, red gum, cypress, maple, spruce, including both eastern and western varieties, redwood, tupelo, poplar, and birch.

The principal lumber-producing states in order of importance are: Washington and Oregon, both of which produce vast quantities of Douglas fir and western hemlock, ponderosa pine and Sitka spruce; California, which produces largely ponderosa pine and redwood; Louisiana, which is the state producing most southern pine; and Alabama, Mississippi, Texas, North Carolina, South Carolina, Florida, Arkansas, Idaho, and Virginia — all of which are important producers of southern pine and to a lesser extent of hardwoods except Idaho.

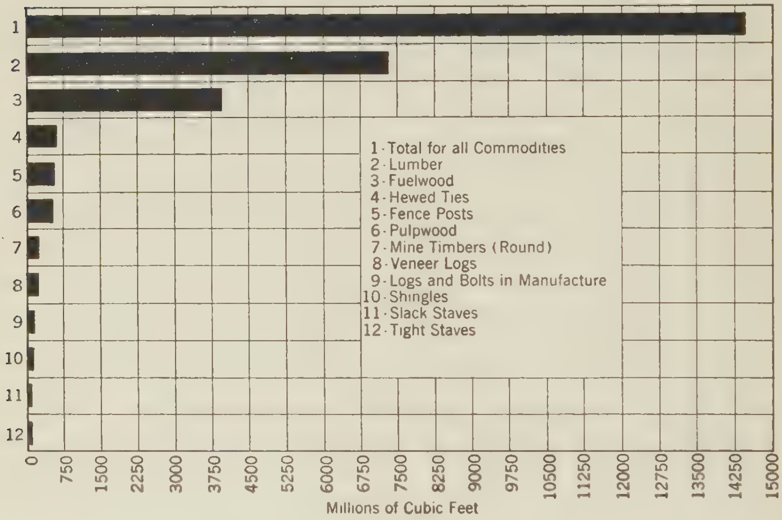

FIG. 107

Idaho is an important producer of ponderosa and western white pine and Virginia produces southern pine and hardwoods.

Oak is cut from a large number of species of both white and red oak classifications and comes principally from Tennessee, Louisiana, Mississippi, and Arkansas, named in order of importance. Red gum is produced principally in South Carolina, Louisiana, and Mississippi. Maple is cut chiefly in Michigan, Wisconsin, and New York, listed in order of importance.

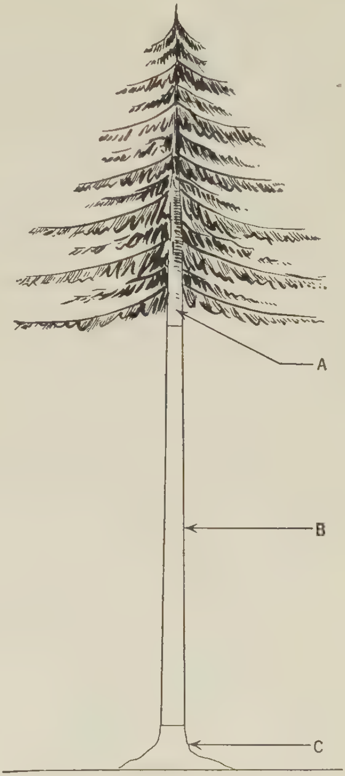

FIG. 108.—Principal woods losses in felling trees. *A*—tops, limbs, and branches 12½%; *B*—defective and decayed trunks and boles shattered in felling 5½%; *C*— stump 3%. Improper log lengths, decay in storage and transportation losses 2%; or a total of 23% of wood volume wasted in the woods. *B* also includes 77% of the wood volume of the tree represented in good logs that go to the sawmills. The total woods losses are 23% and total manufacturing losses 43%, thus leaving only 34% for lumber from the trees as actually felled in the woods.

Waste in Conversion of Timber to Lumber

The principal reason that forest utilization is so important is the wastage attending the conversion of standing timber into lumber and other useful forms. Most of the trees felled in our forests are not used. Under our economic conditions most of this waste is unavoidable. Hodgson found that more than 6 million cords of good sound wood, or 42 cords per acre, are left unused on logging operations in the Douglas fir forests of the Pacific Northwest. This is almost enough to supply the entire pulp and paper industry with its yearly requirements. In the last century only the butt, or first log, was taken, the remainder being left to rot. In Pennsylvania millions of hemlock trees were felled for bark for tannin alone and the remainder of the stems left in the woods. Even today it pays to fell only the largest Douglas fir, sugar pine, and ponderosa pine trees. About one-third of the enormous wastage in felling trees occurs in the woods, the larger share occurring in manufacturing the logs into lumber.

On the basis of recent studies the wastage is converting standing trees into lumber is as follows:

Woods Losses	Percentage of Total Wood Volume Wasted
Stumps	3.0
Tops, limbs, and branches	12.5
Defective and decayed trunks and boles shattered in felling	5.5
Miscellaneous, such as improper log lengths, transportation loss en route to destination, decay in storage, etc.	2.0
Total	23

Manufacturing Losses	Percentage of Total Wood Volume Wasted
Bark	8
Saw kerf	10
Slabs	9
Edgings and trimmings	8
Seasoning	4
Remanufacture	3
Miscellaneous	1
Total	43
Total woods and manufacturing losses	66

Thus, only 34% of the trees felled in the woods is actually used. The largest waste occurs in low-valued stumpage of the Douglas fir, western hemlock, Sitka spruce, and the redwood of the Pacific Coast. Conversely, wastage in Idaho white pine, northern white pine, oak, yellow poplar, basswood, and black walnut is exceedingly small. Therefore, the higher the stumpage value the lower the percentage of waste. If cheaper logging methods are used, the value of standing timber is thereby increased. Consequently foresters should be interested in devising methods of the lowest possible cost for logging and sawing trees and preparing them for market.

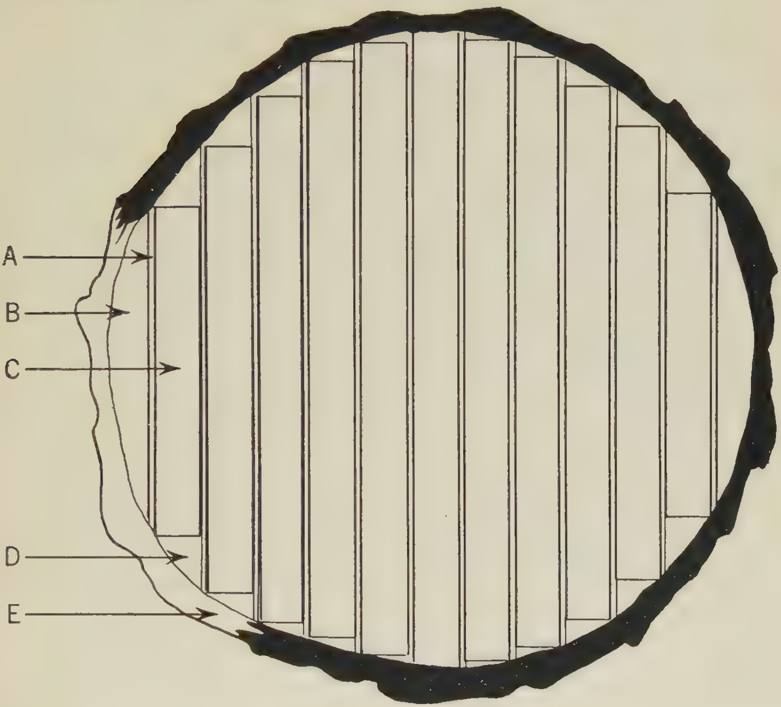

Fig. 109.—Principal manufacturing losses in the conversion of logs to lumber.

A, sawdust from saw kerf	10%
B, slabs	9%
C, lumber	34%
D, edgings and trimmings	8%
E, bark	8%

There are also seasoning, re-manufacturing, and miscellaneous losses totaling 8%. Thus the total manufacturing losses are 43% of the total volume of the tree.

Contrasted with American practice, about 95% of the wood grown in western European forests is utilized. Even the bark, twigs, leaves, and other forest débris are used by the peasants.

CHAPTER XII

PRINCIPAL FOREST PRODUCTS AND THEIR UTILIZATION

Major Forest Products

A vast array of products is annually taken from the forests to serve the manifold social and economic requirements of man. While lumber has been and is likely to continue to be the principal product of our forests, there are many other products. In recent years, with the development of chemical utilization, increased attention has been given to such derived products as cellulose, lignin, acetate of lime, rayon, and artificial leather.

The great bulk of the primary product of the forest is logs from which lumber, pulpwood, poles, piling, posts, and many other commodities are made. Thus foresters must constantly analyze the present and prospective markets for the produce of our woods. Wherever the trends of this demand may lead, however, the pioneer attitude of destruction and exploitation is being replaced with an attitude of conservation and perpetuation.

During the upbuilding of the great Central West, before and after the Civil War, about 60,000 farms were established annually. This development of home building required huge quantities of lumber from the white pine of the Lake States and the southern pine of the South. This expansion and building activity reached its peak in 1907 when 46,000,000,000 b. f. were consumed, the all-time peak of lumber production. This heavy demand for lumber induced unjustified speculation in stumpage. Some forestry enthusiasts predicted timber famines and dire shortages within a decade or two. The speculation in and acquisition of large timber holdings in the Pacific Northwest form the basis of many of our major forest problems.

Annual taxes per acre increased from 10–14 cents in 1907 to 75–98 cents two decades later.

Although the demand for lumber has decreased since 1907, there has been a concurrent drop in per capita consumption. Prices for lumber have been usually much lower since the peak in 1920, but the relative proportion of forest products cut in our forests has remained more or less static for several years.

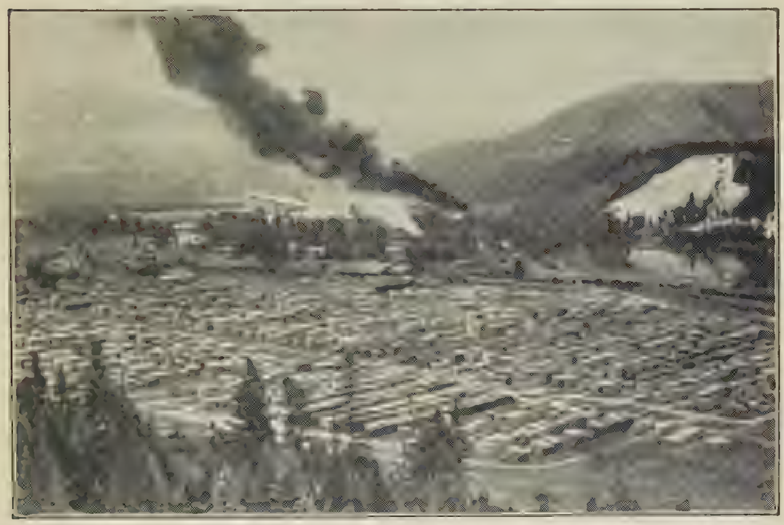

Fig. 110—One of the many large sawmills in the West which convert relatively low value stumpage into high priced lumber. There are about 26,000 sawmills in the country, cutting from 5,000 to a million b. f. each, per day. These forest industries are the main sources of employment and therefore of community life and development in many sections of the country. It is important that forest growth be properly maintained to provide materials for the permanent activity of these wood using industries. With the passing of our vast virgin resources will come the passing of the large sawmill units.

About the year 1900 nearly as much wood was consumed in the form of fuelwood as lumber. With the increasing use of coal, fuel oil, natural gas, electricity, artificial gas, etc. the demand for fuelwood has dropped off enormously, to almost half of what it once was. The demand for pulpwood, veneer logs, and cooperage has increased during recent years.

The following table shows the percentage of the demand for forest products during recent years.

PRINCIPAL FOREST PRODUCTS USED ANNUALLY[1]

Forest Products	Yearly Use Million Cubic Feet	Percentage of Total Used Annually
Lumber	7371	50.8
Fuelwood	4002	27.6
Hewed ties	633	4.4
Fence posts	629	4.3
Pulpwood	588	4.1
Mine timber (round)	232	1.6
Veneer logs	231	1.6
Cooperage (slack)	162	1.1
Logs and bolts in manufacture	156	1.1
Cooperage (tight)	141	1.0
Shingles	139	0.9
Miscellaneous (poles, piling, export, logs, distillation, and extract wood, excelsior, etc.	211	1.5
Total — All items	14,495	100.0

[1] Bureau of the census, 1925—1929.

In this table the total volume of timber cut represents 14,495,308,000 cubic feet. Lumber, which represents about one-half the total, comprised 38 billion b. f. Other forms of products are measured in cubic feet because they are not manufactured or sold in terms of board feet.

Lumber Uses

Lumber is used in a great variety of ways. There are said to be over 2000 different uses of lumber. One may classify these uses in three broad divisions, the principal one of which is the construction industries. These industries include railroads, farms, highways, bridge and harbor work, housing, factory building, etc. and consume about two-thirds of the total quantity of lumber. Second in importance are the wooden package industries which include the manufacture of boxes, crates, and similar containers and normally consume 15% of

3 DIV. OF USES: 1/ CONSTRUCTION
2/ WOODEN BOXES
3/ HANDLES MACHINERY FURNITURE

the total quantity of lumber. The remaining 18% goes into a great variety of industrial uses in the manufacture of handles, machinery, furniture, automobiles, and a myriad other articles. A small amount of lumber is exported.

Lumber uses, therefore, may be summarized as follows:

Construction industries	67%
Wooden packages (boxes, barrels, crates, etc.)	15%
Industrial uses and export lumber	18%
Total	100%

Lumber consumption generally follows population concentration. Whereas lumber is produced chiefly in the Northwest and South, it is consumed chiefly in the Northeast. Thus lumber merchandising involves long hauling distances and consequently high costs for transport.

The principal lumber-consuming states are New York, Illinois, California, Michigan, Pennsylvania, and Ohio. Approximately $40,000,000 are spent annually in New York State for transportation charges to bring lumber chiefly from the Far West and the Far South.

Hardwoods, for the most part, find their market in the manufacture of furniture, automobiles, machinery, tools, implements, and similar articles; the softwoods are used principally for general construction purposes. In dwellings, the frame, siding, and sheathing are always constructed of softwoods, whereas floors are generally of hardwoods or softwoods. Railroads use vast quantities of both hardwoods and softwoods for cross ties. Construction timbers of 6″ × 6″ size, and larger sizes up to 12″ × 12″, are exclusively made from the softwoods — principally Douglas fir and southern pine. Wooden packages are made from both hardwoods and softwoods.

The larger softwood areas are located in the Far West and South; the hardwood-producing areas are found principally in the states of the lower Mississippi Valley. Lumber reaches its markets from the South chiefly by rail, but the western lumber produced near tidewater is usually shipped to the East by boat, through the Panama Canal.

Thus there are critical cross-currents of intensive competition between the Far West and the South for the important markets of the Northeast, East, and Middle West. Water rates are much cheaper than rail rates; therefore, it is frequently possible to bring lumber from Seattle and Portland to New York via the Panama Canal (a much greater distance) at less cost than to ship it by rail from Louisiana, Alabama, and Texas to the same destination. Lumber destined for such interior points as Buffalo, Pittsburgh, and even Detroit is frequently shipped from the West Coast to the Atlantic seaboard and transshipped via rail to the nearest interior point. Lumber is trucked for distances as great as 200 miles from the Atlantic seaboard, but the great volume of lumber movement is by water and rail rather than by motor truck.

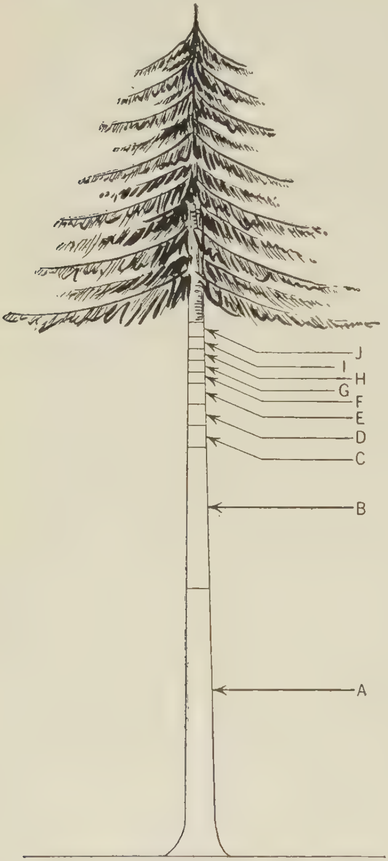

Fig. 111.—How our timber is utilized. A — lumber 51%, B — fuelwood 28%, C — hewed ties 4%, D — fenceposts 4%, E — pulpwood 4%, F — cooperage 2%, G — mine timbers 2%, H — veneer logs 2%, — shingles 1%, J — miscellaneous 2%.

Principal Forest Products Other Than Lumber

The tables shown earlier in this chapter indicate that lumber composes about one-half the forest products and a great variety

SECONDARY FOREST

of wood products the other half. In order of importance these are fuelwood, hewed cross ties, fence posts, pulpwood, mine timbers, veneer logs, cooperage, shingles, and other miscellaneous products.

These products are derived from the woody trunk of the tree. Other products not measured in wood volume, but still exceedingly important, are obtained from the sapwood or growing parts of the tree. They include naval stores, which yield turpentine and rosin of commerce, maple syrup and sugar from the sugar maple tree, commercial rubber from the planted rubber trees of the tropics, and oils, drugs, chemicals, medicines, colors for dyeing materials, tannins, etc.

Products may be classified according to their uses. (1) There are the construction materials, such as lumber, timber, cross ties, poles, piling, posts, mine timbers, bridge planks, and shingles. (2) There are chemical derivatives, such as pulpwood, naval stores, tannin, dyewood, distillation products, rubber, maple syrup and sugar, etc. (3) There are wooden packages and containers, such as slack and tight cooperage, boxes and crating, and veneers, which are used largely for containers. (4) Finally, there are such miscellaneous products as fuelwood, which is the most important product of the forest next to lumber, bolts or sections of the tree stem used for excelsior, vehicle and implement stock, cork from the cork oak of the Mediterranean region, novelties, and toys.

Forest products may also be classified according to primary or secondary products of the forest, that is, according to whether they need little or considerable further refinement and manufacture before they are usable. Poles, piling, mine props, and lagging are examples of primary products. Secondary products, which require manufacture and perhaps further refinement, include lumber, sawed cross ties, shingles, cooperage, veneers, boxes and crates, hardwood dimension, automobile body parts, and planing mill products. Another classification may be those products reduced by chemical means, such as paper and pulp, rayon or artificial silk, cellophane, and the distillation products — acetate of lime, wood alcohol, and charcoal — tannins from oak and hemlock bark, chestnut wood and various other materials, dyestuffs obtained from osage orange, and many foreign products and naval stores.

Furthermore, there are products made locally in various parts of the country. These furnish a means of livelihood and employment and may be of great importance regionally if not nationally. Examples of these are cascara bark in the Pacific Northwest; Christmas trees, holly, mistletoe, and other Christmas greens in many parts of the country; Spanish moss, which grows abundantly in the South Atlantic and Gulf Coast States; spruce gum in the North and Northeast; and such decorative plants as wild flowers, mountain laurel, and rhododendron in the Appalachian mountains and mountainous sections of the East.

Some of the more important products aside from lumber are briefly described as follows:

1. Fuelwood. This is the most important product in volume next to lumber. Until the introduction and use of coal, oil, natural gas, and electricity for fuel, wood provided the only fuel available. For many centuries in Europe, and during the early days of this country, wood was the principal forest product. The average farm consumption of fuelwood is about 17 cords per year. Fuel value is closely related to specific gravity, and the most valuable hardwoods in order of importance are: hickory, oak, beech, birch, maple, ash, and elm. The best softwoods for fuel are tamarack, longleaf pine, Douglas fir, other southern pines, and lodgepole pine. One man can fell, chop, and stack one cord of wood per day if experienced in the work. A cord is 8′ long by 4′ high and is made of pieces 4′ long. Hogged fuel from sawmill waste is widely used in the Pacific Northwest for fuel. Enough wood is annually wasted in our forests to supply all the fuel we need, but transportation costs are prohibitive.

2. Cross ties. The railroads normally use around one hundred million cross ties annually. For the heavy traveled railroads, such as the Pennsylvania and the New York Central,

a cross tie 7″ × 9″ × 9′ is usually specified. Smaller ties, 6″ × 8″ × 8′ and 8″ × 8″ × 8′, are commonly used by some of the railroads. More and more cross ties are being sawed rather than hewed, which is a very wasteful process of conversion. The principal woods used for cross ties are oak, southern pine, various hardwoods, Douglas fir, ponderosa pine, and lodgepole pine. Most of the cross ties are treated with creosote or zinc chloride, a treatment which prolongs their life.

3. **Pulpwood — rayon and fiber boards.** Southern pine is rapidly approaching spruce as our principal pulpwood. The industry is moving to the South where an abundant, cheap, and quick-growing pine is being successfully used. Pulpwood there, costing only $4 to $6 per cord at the mill, compares with a price of $10 to $12 or more for spruce in the North and Northeast. About 7 millions of cords are used annually for

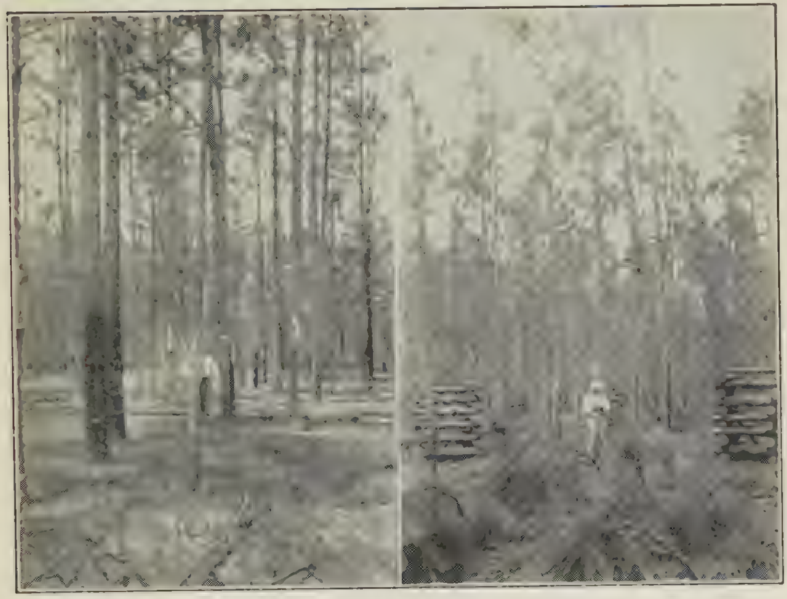

Fig. 112.—Typical southern pine pulpwood stands, the one on the left before cutting in Alabama and the one on the right after producing several cords per acre. The one on the left has been turpentined.

pulp and paper. Pulpwood is made by the groundwood or mechanical process, which produces the pulpwood used for newspapers, the sulphite method, which is the most important method of chemical reduction, the sulphate process, which is applied widely to southern pine and hemlock and used principally for Kraft papers, and the soda process, which is applied chiefly to hardwoods — beech, birch, maple, tupelo and black gums, aspen, cottonwood, and yellow poplar. Several large plants in the South are using hardwoods by the soda process. Vast quantities of rayon have been manufactured in connection with our pulp and paper industry. Most of these processes are secret. Recently over 157 million pounds of pulp were used for rayon and cellophane.

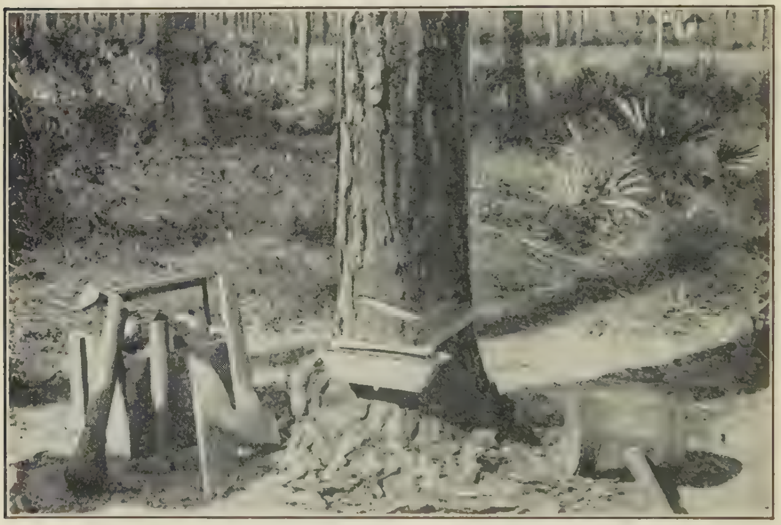

FIG. 113.—A tree faced with initial chipping, and apron and gutter used to guide the resin into the cup. At the left are shown the chipper, broadaxe, and other tools. On the right is a maul that is used to drive the broadaxe into the tree to make the cut for the aprons.

4. Over 200 varieties of insulating and building fiber boards are now available on the market. Several of them use sawmill and woods waste, so that they assist very materially in

converting materials otherwise wasted into useful commodities. These insulating and building fiber boards are made by chemical and mechanical processes. Wood, asbestos, bagasse from sugar cane, cork, cornstalks, mosses, gypsum, and other materials are used as bases for these boards. Enormous quantities are now turned out for these purposes.

5. Naval stores. The longleaf and slash pines of the South produce resin when an incision is made in the bark. When distilled, this resin is converted into turpentine and the residue screened and graded into various types of rosin. This is one of the first industries developed in Colonial days. It is now centered in Georgia and northern Florida, in second-growth pine, although it is found throughout the South wherever the two above-mentioned species grow. Great wastage has attended the production of naval stores. Foresters urge that no trees less than 9″ d.b.h. be tapped. At the peak of production, over 38 million gallons of turpentine and 4288 barrels of rosin were marketed in one year. The trees are chipped once a week during the warm season, from March to October, and the flowing resin collected in cups or metal containers in orchards or units known as crops of 10,500 faces.

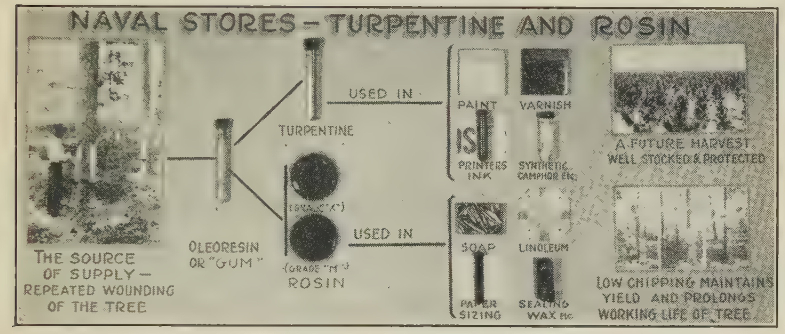
NAVAL STORES – TURPENTINE AND ROSIN
THE SOURCE OF SUPPLY – REPEATED WOUNDING OF THE TREE
OLEORESIN OR "GUM"
TURPENTINE
USED IN
PAINT
VARNISH
PRINTERS INK
SYNTHETIC CAMPHOR ETC.
(GRADE "X")
(GRADE "M")
ROSIN
USED IN
SOAP
LINOLEUM
PAPER SIZING
SEALING WAX ETC.
A FUTURE HARVEST WELL STOCKED & PROTECTED
LOW CHIPPING MAINTAINS YIELD AND PROLONGS WORKING LIFE OF TREE

FIG. 114.—Diagram illustrating the primary and secondary products of the naval stores industry as practiced in the longleaf and slash pine forest of the South.

6. Cooperage. Within recent years the cooperage industry has greatly expanded for both tight cooperage, which means

barrels for holding liquids, and slack cooperage, which is used for shipment of such non-liquid materials as flour, sugar, lard, fish, paint, vegetables, fruits, hardware, crockery, and rosin. White oak is the principal wood used for tight cooperage and red gum, beech, birch, maple, tupelo, and southern pine are used for slack cooperage.

7. **Veneers and plywood.** The demand for wood for these purposes has advanced strikingly during recent years. Principal woods used are Douglas fir, red gum, southern pine, and ponderosa pine. Enormous quantities are used for shipping containers, even for automobiles and automobile parts, furniture, and commodities of several kinds. Plywood (layers of 3 or more layers of veneer) is also used for built-up stock for doors, panels, furniture parts, drawer bottoms, and automobile bodies. Plywood has replaced lumber for many purposes. Veneers (thin sheets of wood) are made by three processes, namely: (1) the rotary method, by which a large log is turned against a knife cutting off continuous sheets of wood; (2) the slicing method, by which sharp knives slice off veneers from a stationary flitch; and (3) sawed veneers, in which there is great wastage. Plywood for built-up stock is made by placing three, five, or more sheets of veneer with the grain at right angles to each other. By gluing the sheets, a very solid and substantial board is formed, useful for many purposes. Veneers are usually cut from one-eighth inch to one-twentieth inch in thickness.

8. **Miscellaneous.** There are other important products. (*a*) Tannins, found chiefly in the bark and leaves of some species, such as hemlock, oak, chestnut wood, and sumac leaves and twigs. Tannins are also obtained from quebracho from South America and various barks and nuts from the tropics. (*b*) Several processes of destructive distillation are used to obtain acetate of lime, wood alcohol, and other products. In the South even rosin, turpentine, and pine oils are obtained by various distillation processes. Many of our films, chemicals, medicines, etc., are obtained from wood distillates. The

principal hardwoods used are beech, birch, maple, and hickory. Steam distillation is often applied to southern pine to recover rosin, pine oil, and turpentine. (*c*) Vast quantities of maple syrup and sugar are obtained from the sugar maple in the Northeastern and Lake States. Vermont is the center of the industry. (*d*) Enormous quantities of rubber are now obtained from the rubber plantations of the Dutch East Indies and West Africa. (*e*) Cork in large quantities is imported into this country for linoleum, stoppers, and various other purposes. (*f*) Vast quantities of poles, piling, fence posts, grape stakes, bolts for excelsior, and many other materials not mentioned above are annually obtained from our forests. Altogether they aid very materially in the employment of men and the happiness and prosperity of communities. The vast resources available for these materials should be conserved and maintained for the future prosperity and welfare of the country.

Value Relationship of Standing Timber and Retail Lumber

There is a wide latitude between the value of standing timber and the finished product delivered to the ultimate consumer. Stumpage value of standing timber represents a very small part of the production costs. Stumpage value may represent from 10 to 16% of the value of lumber f.o.b. the sawmills, but only 3 to 10% of the value of lumber delivered to the ultimate consumer for such purposes as the construction of a house or a new garage or a bridge. Lumber produced in Washington and Oregon must compete with lumber of different species but of similar grades and sizes produced in Texas and Louisiana for the building operations in Massachusetts, Pennsylvania, or Ohio. This competition has always been very intense. It is frequently true that transportation costs are greater or approximately equal to the f.o.b. mill costs. Standing Douglas fir timber may be worth $2.50 per m. b. f.; when manufactured it may sell for $20.00; when delivered in New York $33.00; and the retailer, after handling, hauling, and storing it, may charge $48.00 for it.

A large portion of the cost of producing lumber, from standing trees to the finished product delivered to the final consumer, is represented in labor charges for employment. Standing timber at some remote location in the wilderness may be worth very little but when felled, hauled long distances to the sawmill, and converted into sizes and grades which are in demand in the general lumber market, this value may appear to be relatively high. There is a general tendency to produce lumber in more and more remote locations and at greater distances from the markets.

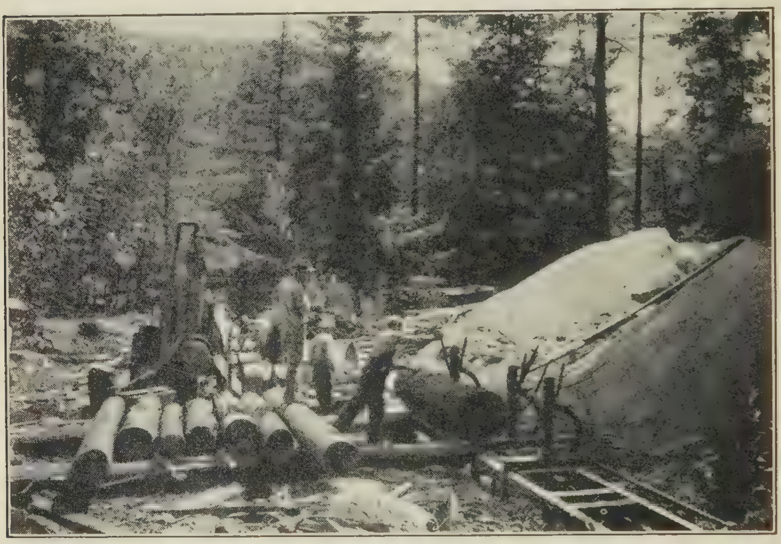

FIG. 115.—Typical portable sawmill as found in the hardwood forests of western Virginia. Most of our lumber east of the Rocky Mountains is now being produced at small sawmills, which are the principal outlet for the products of the forest. Lumber constitutes about one-half the total forest products in this country.

There is a vast difference in the type of labor employed in different parts of the country in both woods and sawmill operations. Generally the inefficient Negro labor of the South receives far lower rewards expressed in wages than the highly efficient labor in the mechanized operations of the Northwest, where the hourly wage may be relatively high.

Estimates made of the average selling price of manufactured lumber, especially of Douglas fir and southern pine, the two most important, indicate that logging and sawmilling represent 46% of the total cost, transportation of lumber 30%, and distribution 22%. These figures include such overhead items as taxes, interest, insurance, amortization, and depreciation.

Lumber is frequently sold at relatively little profit. As these figures indicate, the manufacturer receives less than half the ultimate cost of lumber, the cost for the consumer. First the trees must be cut down, then cut into log lengths, skidded to central loading points called landings, then hauled to the sawmills. Here the logs are converted into lumber by band or circular saws. Then a trained, skilled, and expensive sales organization must merchandise the product to the retail lumber yard or to some industries using lumber. Lumber is a bulky and heavy commodity and is a very expensive material to handle.

The following tables show the principal items that enter into the cost of producing lumber, from standing timber to ultimate delivery to the house under construction or wherever the lumber may be used:

LUMBER COST AT CHICAGO, ILLINOIS[1]

	Douglas Fir	Southern Pine	Western Pine	Oak
Stumpage	$ 2.42	$ 4.31	$ 2.11	$ 6.31
Logging and milling	11.69	13.71	14.12	16.18
Selling and administrative	4.69	7.23	7.21	7.99
Freight	20.16	11.40	11.73	12.75
Shipping weight per M ft.	2,800 lb.	3,000 lb.	2,300 lb.	4,300 lb.
Freight rate per 100 lb.	.72	.38	.51	.295
Retailers costs	17.73	16.68	16.00	19.68
Cost to consumer	$56.69	$53.33	$51.17	$62.91

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[1] Costs are based upon a recent period. Data from "Economic Problems of the Lumber and Timber Products Industry," National Recovery Administration, Washington, D. C., 1936.

LUMBER COST AT NEW YORK, NEW YORK[1]

	Douglas Fir (By Water)	Douglas Fir (Rail)	Southern Pine	Western Pine	Oak
Stumpage	$ 2.42	$ 2.42	$ 4.31	$ 2.11	$ 6.31
Logging and milling	11.69	11.69	13.71	14.12	16.18
Selling and administrative	4.69	4.69	7.23	7.21	7.99
Freight	10.20[2]	24.36	11.10	16.79	17.75
Shipping weight per M ft.	3,100 lb.	2,800 lb.	3,000 lb.	2,300 lb.	4,300 lb.
Freight rate (R.R.) per 100 lb.		.87	.37	.73	.41½
Retailer's costs	14.24	21.21	17.86	19.77	23.72
Cost to consumer	$43.24	$64.37	$54.21	$60.00	$71.95

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[1] Costs are based upon a recent period. Data from "Economic Problems of the Lumber and Timber Products Industry," National Recovery Administration, Washington, D. C., 1936.

[2] Water shipment rate from West Coast to New York is expressed in m. b. f.; others are rail rates.

Substitutes and the Decreasing Demand for Lumber

Since 1906 there has been a steady decline in the trend of lumber consumption. In fact, per capita consumption has declined about 50%. If the rate of consumption prior to 1906 had continued, we should have required about twice as much lumber in 1929 as was actually used. For about a century following 1809, the trend of lumber consumption was definitely upward. The per capita consumption of lumber rose to 525 b. f. in 1906 and steadily declined to 305 b. f. in 1928 and 130 b. f. in 1932. Since then it has risen to about 190. Trends in public taste, and especially new forms and economies in raw materials, are responsible for the changes in lumber uses. No doubt the fear of a timber famine has caused people to feel that lumber has reached high or prohibitive prices. As a matter of fact, the recent f.o.b. mill price for lumber has been about as low in some sections as it was in the period of 1900–1910. Concentration of population in the large cities, especially in apartment houses, building restrictions in the larger cities, skeleton steel construction, veneered coverage, increased use of fiber boards, trends toward more permanent forms of construction, etc., have caused changes and decreases in lumber consumption. Metal lath, various forms of building boards and insulating materials, metal automobile bodies and airplanes, steel desks and furniture, metal doors, sash and trim, concrete bridges, piling, posts, sidewalks and foundations, asbestos and tile roofing, metal poles and posts, all are examples of current substitutions for lumber. To offset the introduction and use of these substitute forms, however, new uses are constantly being found for wood. Wood is a material of such wide and universal use, owing to its workability, cheapness, durability, beauty, warmth, and many other qualities, that it will always be in demand for purposes for which it is best suited. Because of these qualities wood cannot satisfactorily be replaced in the construction of cross ties, shipping containers, flooring, furniture, and many other similar articles. When treated for durability or fire resistance, wood proves to be a material of very wide utilitarian values. When a satisfactory and inexpensive method of treating wood to make it fireproof or fire resistant is found, the demand for wood will greatly increase. It is important that foresters should defend and advance the use of wood for all purposes where it is best suited. There are many popular misconceptions about the use of wood. Wood will always have a place and a wide demand in our national economy.

CHAPTER XIII

WOOD TECHNOLOGY — STRUCTURE AND PROPERTIES

General

Every species varies in its wood structure and it is this difference that we depend upon to identify our various woods.

A study of wood structure, together with the physical, mechanical, and chemical properties, determines the uses to which each species is adapted. For example, we know that some trees, like chestnut, oak, and longleaf, are durable and are therefore used for railroad ties; Douglas fir is strong and stiff and makes a good construction timber; spruce has long strong fibers and is comparatively free from resin and so is used for paper pulp; mahogany seasons well, does not warp or twist, and has a beautiful grain, all of which make it of especial value for fine furniture and cabinet work; elm is tough and therefore makes a good vehicle and hoop wood; white oak is impervious to liquids and does not impart a disagreeable odor or flavor and so makes a desirable tight cooperage wood.

Each wood has certain characteristics which distinguish it from others in color, weight, grain, strength, stiffness, etc. These characteristics determine the value of every wood for the various lines of utilization and, therefore, to a large extent, together with their available supply, their value on our timber markets.

Some of our species are becoming so rapidly depleted that substitutes are being introduced to take their places. In some cases, ingenious methods have been devised to imitate the grain and color of our more valuable woods. For example, red gum, a comparatively cheap wood, is largely used to imitate black walnut and Circassian walnut. In England it sells as satin walnut. Red birch is sold to a considerable extent as mahogany in furniture and cabinet work, and many new foreign species are being imported and sold as the true mahogany. A new method of graining cheap woods to imitate quartered white oak is now in common use.

The knowledge of wood structure is, therefore, vastly important in identifying the many different species that enter our American markets, both foreign and domestic species.

One of the matters of especial interest in wood technology is the chemical utilization of the enormous quantities of wood waste incident to our present methods of logging and lumber manufacture. New methods are being constantly devised to produce gases and distillates in commercial quantities from several of our timber trees. In Germany, cattle food has been made for some time from sawdust; new processes are being discovered in the chemical reduction of wood fibers for the manufacture of paper pulp; and improved methods of chemical distillation open up a large field for future development.

Wood Structure

Wood structure and arrangement of the woody tissues may be said to underlie the principles that govern both the means of identification and the uses to which our woods are put.

Structure refers to the relative size, shape, and form of the wood element peculiar to each tree. It explains why some species are heavier, stronger, and stiffer than others, why some are cross-grained or straight-grained, hard or soft, and why some have a tendency to check and split, while others season rapidly and without injury. The structure of the oak with its wide medullary rays explains why this species has such a pleasing effect when it is quarter-sawed and polished to bring out the grain.

Bark. The bark serves chiefly as a protective covering. It usually forms from 7 to 15% of the whole contents of the stem. It is much thinner on young than on old trees and is much thicker at the base than farther up the tree. There are successive layers of bark acquired in the same way that successive layers of wood are laid on each year, but they are very indistinct.

The bark often serves as a means of identification. It is very thin in the spruces, cedars, birches, cypress, larch, longleaf pine, etc. It is usually thick in Douglas fir, white pine, yellow poplar, redwood, and some of the oaks.

The bark of many trees is of high value. For example, the bark of the cork oak (*Quercus suber*) of southern Europe supplies our cork of commerce; the bark of the hemlocks and most of the oaks is of high value for tanning purposes. Birch bark was formerly used for canoes; other barks are of high medicinal or fuel value. The fibrous inner bark of basswood is often used in the manufacture of fiber cloth, rough carpets, and mattings.

Sapwood and Heartwood. Inside the bark is the sapwood, usually light in color, varying in width from one-half inch to several inches. Within the sapwood and in the center of the tree is the heartwood, usually much darker in color.

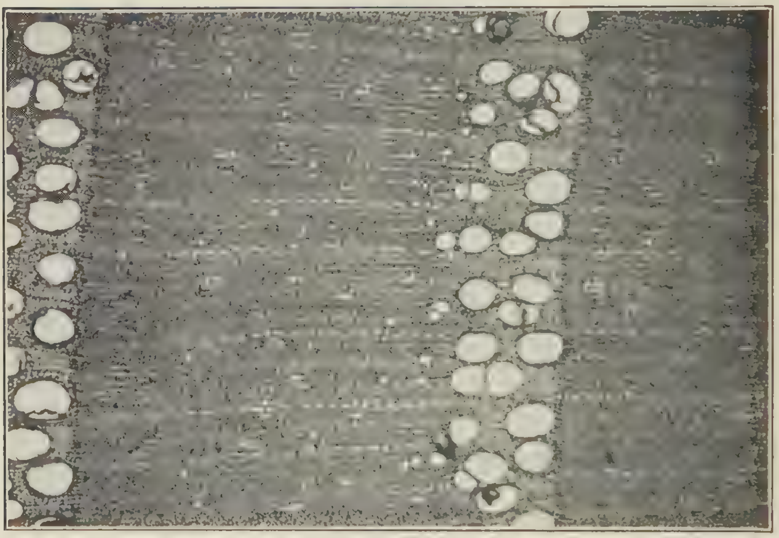

FIG. 116.—Microscopical cross section of ash, a typical ring porous wood. Oak, chestnut, hackberry, ash, and others show a series of large pores along one edge of the annual growth ring. This shows one complete year's growth and parts of two others highly magnified.

The heartwood has practically no other function than that of mechanical support. On the other hand, the sapwood is a living part of the tree, serving largely to store up the starch and to conduct the unelaborated sap from the roots up to the leaves. At the extreme outer periphery of the sapwood is the cambium layer where the growth of the tree in diameter takes place by cell division during the growing season.

The percentage of sapwood is the greatest in young trees. The sap varies, however, with the species. The following species have thin sap as a rule: redwood, catalpa, locust, red cedar, and yew. The following usually have wide sap: hickory, maple, ash, beech, and some of the pines. In some species, such as cottonwood, willow, spruce, fir, and hemlock, there is little difference in appearance between heart and sapwood.

The darker color of the heart is usually caused by the deposition of tannin, gums, resin, etc., and therefore the heartwood is heavier, more durable, and contains less moisture. These qualities often render it the most valuable portion of the tree. However, for handles, spokes, spools, and certain other wooden articles, only sapwood is used; for example, hickory is used for handle stock. Sapwood can be impregnated readily with chemical preservatives and in the natural state seasons with much difficulty. It is much more susceptible to decay, owing to its greater moisture content.

Annual Rings and Grain. Grain refers to the direction and width of the growth rings. Sawed boards are often cross-grained because the line of the saw cut does not follow the grain. This explains why split wood is stronger than sawed wood. Therefore bolts for manufacture into spokes, handles, tight cooperage, etc., are preferably split rather than sawed.

Species with wide pith or medullary rays, such as oak, beech, and sycamore, yield a beautiful silver grain when sawed radially, or at right angles to the annual rings. Wavy and curly grain are common variations in the growth of many of our species, especially hard maple and yellow birch.

As explained in previous chapters, the width of the annual rings depends upon the species, conditions of growth, etc. All trees grow relatively fast in the spring and slowly toward the end of the growing season. The wood elements are therefore much coarser during the first part of each year's growth. This gives rise to the differentiation between springwood and summerwood. This distinction is brought out very markedly in the southern pines and in Douglas fir. The springwood is light in weight and in color; the summerwood is dark in color and heavy, giving the common ribbed appearance of these woods when cut across the grain. This difference can also be readily seen in any flat-grained lumber of nearly every species.

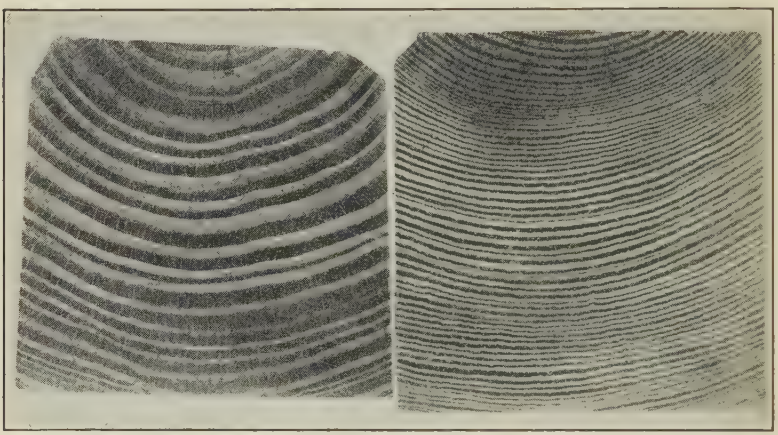

FIG. 117.—Cross-sections of one of the most promising and rapidly growing trees in the South, known as slash pine. On the left the section shows rapid growth and on the right slow growth, but there is a large proportion of dark or summerwood compared with the lighter colored springwood in each section. This is the basis of the density rule. Wood of this species is hard, heavy, durable and strong and, therefore, is in wide demand for construction purposes.

Hardwood versus Coniferous Wood. Custom has been responsible for calling all our broadleaved trees hardwoods, and all our evergreens conifers. These, however, are misnomers in both interpretations because there are certain conifers, like larch and cypress, which are not evergreen but deciduous, dropping their leaves in the fall. Then, too, many of our hardwoods are much softer in their wood structure than certain conifers or so-called softwoods, and vice versa. For instance, softwoods like larch, longleaf pine, and Douglas fir are much harder than so-called hardwoods like basswood, willow, cottonwood, yellow poplar, buckeye, and red gum. These terms are therefore merely for classification.

Another means of classification for the purposes of identification is according to the porous nature of the various woods.

On examination, in cross-section, even under the microscope, the pores of the softwoods or conifers are found to be not visible or conspicuous. Further classification of the genera and species may be made by means of the resin ducts, color, odor, taste, appearance of heartwood, etc. The hardwoods are divided into two broad groups: (1) Those that are ring-porous, such as oak, ash, hickory, elm, chestnut, catalpa; and (2) those that are diffuse-porous, such as red gum, yellow poplar, willow, birch, maple, basswood, and beech. The ring-porous woods are those with a wide band of large pores in the springwood. The diffuse-porous woods are more homogeneous and continuous in their structure and texture.

Altogether about 80% of our lumber cut is coniferous and is used largely for construction and general lumber purposes. The hardwoods are used principally in specialized lines of utilization, such as furniture, cabinet work, vehicle and implement stock, and fine interior finish and flooring.

Weight of Wood. The species vary a great deal in weight. Most woods float in water because they are lighter than the water which they displace, but this is because of the air contained in the wood. When these air spaces are filled by water in driving and rafting, the logs become " water-logged " and sink. This is explained by the fact that wood substance is about 1.6 times as heavy as water, and this holds true of such light woods as poplar and basswood as well as of heavy oaks or pine. Weight, therefore, depends upon the number of wood fibers and the thickness of their walls.

Weight is very important in identifying woods and in determining their usefulness for various purposes. Fuel value is in direct ratio to weight. The transportation of logs from the woods to the mill by driving is made possible by their relative floatability. This explains why driving cannot be practiced in logging hardwoods. In transporting logs or lumber, weight is an important factor in the cost of the operation.

The weight of wood is usually expressed in terms of specific gravity, that is, its relation to the weight of an equal volume of water weighed at a temperature of 4°. A cubic foot of pure water usually should be 62.43 pounds. Very few species of trees even approach this weight.

The following table gives the specific gravity of some of our common timbers according to Sargent:

Hardwoods		Conifers	
Species	Specific gravity	Species	Specific gravity
Lignum vitæ	1.14	Western larch	0.74
Mockernut hickory	0.84	Longleaf pine	0.70
Persimmon	0.79	Eastern larch	0.62
White oak	0.75	Loblolly pine	0.54
Hard maple	0.69	Douglas fir	0.52
Beech	0.69	Ponderosa pine	0.47
White ash	0.65	Southern cypress	0.45
White elm	0.65	Sitka spruce	0.43
Black gum	0.64	Eastern hemlock	0.42
Black walnut	0.61	Amabilis fir	0.42
Red gum	0.59	Redwood	0.42
Black cherry	0.58	Lodgepole pine	0.41
Basswood	0.45	Incense cedar	0.40
Chestnut	0.45	Western white pine	0.39
Catalpa	0.45	Eastern white pine	0.38
Black willow	0.45	Balsam fir	0.38
Yellow poplar	0.42	Western red cedar	0.38
Butternut	0.41	Northern white cedar	0.32
Black cottonwood	0.41	Big tree (redwood)	0.29

The above list shows how much heavier, as a rule, the hardwoods are than the conifers and the great variation in weight of each class.

Shrinkage. Moisture in wood is found in three distinct places; namely, in the cell contents, in the cell walls themselves, and in the intercellular spaces. Therefore, when this moisture is released there is a consequent shrinkage in volume as well as in weight.

If wood were a uniformly homogeneous material, this shrinkage would be of minor importance because it would simply result in smaller size. But wood is made up of many complex elements. For example, there are heartwood and sapwood, springwood and summerwood, and pith or medullary rays, all of which vary in their tendencies in the process of drying.

When the top of a freshly cut board is exposed to the sun, it dries more rapidly than the lower surface, with the result that there is greater shrinkage on the top surface and there is warping for a given area. Another illustration is found in the fact that wood dries from the end more rapidly than from a side face; therefore, there is shrinkage and frequently splitting or checking near the end, owing to the unequal drying process. Uneven or too rapid seasoning, therefore, results in checking, warping, and twisting.

Wood shrinks very little along the grain and considerably across the grain. Again, a plain-sawed board will shrink about twice as much in width as a quarter-sawed board.

Roth has determined that for every hundred inches in width, boards of light conifers, such as white pine, spruce, and cedar, will shrink about 3″; those of ash, walnut, beech, elm, and maple about 5″; those of basswood, birch, and chestnut about 6″; and hickory, young oak, and eucalyptus will shrink from 6 to 10″.

Cross-grained woods exhibit great irregularities in shrinkage, and therefore considerable difficulty is experienced in seasoning eucalyptus, elm, black and red gum, beech, and a few others.

Mechanical Properties

Strength. As applied to timbers, strength is a general term used in reference to the ability of wood to resist certain stresses. On investigation it is found that different woods vary quite materially in these respects.

The principal resistant features that go to make up strength are:

1. Resistance to compression along the fibers, as in pillars and dimension timbers in an upright position.
2. Stiffness, or the ability to resist bending, as in floor joists and beams supporting heavy loads.
3. Strength in tension, or the ability to resist a lengthwise stress. Wood is seldom put to this test.
4. Shearing strength, or the ability of the fibers to resist rupture either with or across the grain; for example, the shear of a wooden pin in a mortise.

Moisture is an important factor in the strength of wood. Therefore, to a certain extent, strength increases with the degree of seasoning. Freshly cut or green timber consequently must be seasoned before being used wherever any strength factors are necessary.

Knots or other defects also influence the strength to a considerable degree. The size, character, and location of the knots, however, are of importance. For example, in cross-bending strength, knots on the upper surface of a beam do not detract from the strength nearly as much as knots on the lower part of the beam.

Weight of the wood is also important. Heavy woods are usually of strong structure.

The following are examples of commonly used woods of relative strength as expressed in its several different applications. The strongest all-round woods are longleaf pine, larch, hickory, hard maple, yellow birch, white oak, and black locust. Those of medium strength are cypress, Douglas fir, ash, beech, red oak, chestnut, and sycamore. Some of our weakest woods, in this respect, are white and other soft pines, hemlock, spruce, basswood, yellow poplar, cottonwood, and the western firs.

Hardness. Woods vary a great deal in their hardness, which may be expressed as resistance to indentation or to the saw or axe across grain. Hardness is dependent largely on weight, structure of the wood elements, and degree of seasoning. This feature is important in several methods of utilization, such as flooring, furniture, handles, and many small wooden articles.

The following list shows the relative hardness of some of our more common species in the seasoned form.

Very hard	Hard	Medium	Soft	Very soft
Hickory	Oak	Douglas fir	Ponderosa pine	White pine
Hard maple	Beech	Red gum	Hemlock	Sugar pine
Black locust	Birch	Tamarack	Chestnut	Spruce
Rock elm	Black gum	White elm	Yellow poplar	Redwood
Persimmon	Longleaf pine	Cottonwood	Cypress	Basswood
Osage orange	Ash	....	Cedar	Willow

/ **Cleavability.** The resistance of wood to cleavage along the grain is important when it is desirable to split timbers. The line of least resistance in cleavage is along the radius because the medullary rays are in that direction. Wood splits much more easily when wet because moisture softens the fibers and reduces adhesion across the grain. Straightness in the grain, however, determines to a large degree the ease with which wood splits.

The following list shows the relative splitting qualities of some of our woods:

Difficult to split	Medium	Easy to split
Elm	Birch	Chestnut
Black gum	Maple	All pines
Beech	Hickory	Redwood
Sycamore	Oak	Cedars
Dogwood	Ash	Fir
Red gum	Cottonwood	Western larch

On the whole, most of our woods are comparatively easy to split.

4/ **Miscellaneous.** Other mechanical properties that may be mentioned are flexibility and toughness. For example, hickory and ash are flexible; hemlock and pine are brittle. Moisture content influences flexibility to a considerable degree.

Toughness refers to the combined strength and pliability of a wood. Good examples of tough woods are elm and hickory, which offer high resistance to both tension and shearing.

Chemical Properties

General. As said before, wood is very complex in its structure and each species varies both in its physical and chemical characteristics.

The field of chemical utilization of our forest products has scarcely been touched, in so far as the possibilities are concerned.

Wood dried at 300° F. is made up of about 99% of organic matter and about 1% of inorganic matter. The inorganic elements make up the ash when wood is burned. At the above temperature, according to Roth, wood is made up of the following:

	Percentage
Carbon	49
Hydrogen	6
Oxygen	44
	99

Among the other elements found to a small extent are nitrogen, potassium, sodium, calcium, and magnesium.

Ordinary seasoned wood or lumber contains, in weight, about 25% of water, 74% of wood substance, and 1% of ash.

The wood itself consists of a skeleton of cellulose which contains in the different species varying degrees of lignin, tannin, resins, gums, etc. Cellulose and lignin are readily converted into starch and also into sugar. Although the method is an expensive one, sawdust is now being converted into sugar for animal food and it is already an important source of vinegar.

In the chapter on utilization, the wood distillation industry is briefly described.

Durability. As applied to wood, durability means the ability to resist decay, or simply the length of life of a certain timber under given conditions. Durability is important in connection with those usages where wood is especially susceptible to decay, such as railroad ties, poles, posts, mine timbers, and piling. Durability may also include the influence of mechanical wear, but this is relatively unimportant except in ties.

The durability of the different species is very often the determinant factor in their value for several lines of utilization, especially in timbers in contact with the soil, weather, and water, when used untreated.

Contrary to popular opinion, wood does not naturally decay. All decay in wood is caused by the work of fungi and bacteria which live on the starch and other material in the wood cells and cause the wood structure to break down, leaving the common dry rot, punk, blueing, and rotteness in our timbers. The fungi are spread about by minute seed-like bodies, called spores, which are scattered about readily by the wind.

Fungi live and propagate, and therefore decay is possible only whenever the following necessary conditions are present:

1. Sufficient heat.
2. Moisture in proper amount.
3. Oxygen.
4. Spores of proper fungi or bacteria.

Essential factors for fungi to grow.

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Whenever any or all of these conditions are removed, decay is not possible and, therefore, wood will last indefinitely. For example, some old piling that Caesar used in crossing certain rivers of France about two thousand years ago has recently been exposed and found to be in splendid condition. Irish bog oak is still sound because of the presence of acids in the logs and because air has been absent as the wood lay for centuries beneath the soil. Furniture seldom decays because moisture is absent and the wood finish prevents the entrance of fungi. For the same reason, we paint our houses and artificially inject poisonous antiseptic fluids into the wood fibers of ties, posts, poles, etc., to prevent the destructive work of the wood-decaying fungi. A post rots at the surface of the ground first, because at that point there are the greatest changes of moisture and heat. Sapwood is more susceptible to decay than heartwood because of its greater percentage of moisture and food for fungi and bacteria.

In the living tree the bark acts as a protective covering against decay, but, whenever a fissure or crack is exposed or a limb is broken off, a splendid opportunity is offered for the entrance of the fungi.

There does not seem to be any direct relation between the physical and mechanical properties of wood and its durability. As an illustration, weight, strength, stiffness, hardness or toughness do not seem to have any influence on the durability of any of our woods. Some of these properties however, aid in the prevention of injurious effects of abrasion or mechanical wear. Two of our heaviest woods, hickory and hard maple, are not durable, whereas some of our lightest woods in weight, such as redwood, white cedar, and catalpa, are very durable. Red cedar, a soft wood, is highly durable; beech, a hard wood, is distinctly perishable.

There is, however, usually a definite relation between the color of the heartwood and the durability of many of our woods. The darker the heart, the more durable is the wood, especially in ebony, lignum vitæ, catalpa, red cedar, black locust, osage orange, and several others. Many of our species with light-colored heartwood, such as basswood, maple, hickory, spruce, and tupelo, are very perishable.

The durability of any species depends, therefore, on certain chemical constituents, such as resins, gums, tannin, and other decay-resisting materials. These happen to give a dark discoloration to the heartwood of several of our species; and this phenomenon explains the relation of color to durability.

Rapidity of growth, within a species, is an important factor in its durability, but, as between species, there is no direct inference. For example, rapid-growing species, such as black locust, chestnut, and catalpa, are as durable as such slow-growing species as cypress, longleaf pine, western larch, and the cedars.

The following table shows the relative durability of some of our more common species:

Very durable	Durable	Intermediate	Perishable	Very perishable
Black locust	White oak	White pine	White elm	Black gum
Eastern red cedar	Black ash	Norway pine	Beech	Basswood
Live oak	Cherry	Shortleaf pine	Hickory	Buckeye
Black walnut	Red elm	Red oak	Hard maple	Paper birch
Cypress	Persimmon	Red ash	Red gum	Aspen
Western red cedar	Longleaf pine	Yellow poplar	White ash	Willow
Redwood	Western larch	Butternut	Loblolly pine	Sycamore
White cedar	Eastern larch	Sugar pine	Hemlock	Lodgepole pine
Lawson cypress	Cuban pine	....	Spruce	Balsam fir
....	Ironwood	....	Yellow birch	Jack pine

CHAPTER XIV

TIMBER PRESERVATION

History and Importance

Ever since ancient Roman times, various methods of artificially treating wood to prolong its life have been used. At first, timbers were charred to prevent decay in the ground. Painting the surface of the wood was also frequently resorted to.

The method of injecting chemical preservatives into the wood fibers dates back to 1657, when Glauber, a German chemist of Carlstadt, carried on the first successful experiments. Since that time, the industry has taken wonderful strides and many methods are now in use to prolong the life of timbers most subject to decay, such as ties, posts, poles, piling, mine timbers and construction timbers, wood blocks for paving, etc.

In this country, the first successful timber-treating plant was established at Lowell, Massachusetts, in 1848, and it is still in operation.

Wood preservation is really a means of more intensely utilizing the products of the forest, because, if we can increase the life of certain timbers by artificial and reasonably cheap methods, we shall decrease the demands for wood supplies. This change plays an important part in our forest economy.

The annual loss of wood supplies owing to decay amounts to over 7 billion b. f., or over 70% of all the wood destruction. Another pertinent fact is that our more durable species, such as white oak, cedar, black locust, and cypress, are rapidly disappearing and we are being forced to use inferior species which, often, by a cheap preservative treatment, can be made to last longer than the more durable species in their natural condition.

In 1885 there were only three pressure plants in this country.

The importance of the industry can be at once seen from the following amounts of wood, conservatively estimated, that are now being treated annually:

Class	Amount
Cross ties	34,503,147 pieces
Piling	12,678,607 lineal feet
Poles	2,033,700 pieces
Wood blocks	565,261 square yards
Construction timber	188,199,668 b. f.
Cross arms	567,080 pieces
Miscellaneous	74,481,444 b. f.
Total amount treated	179,438,970 cubic feet

Besides this, large quantities of fence posts, mine timbers, cross arms, and construction timbers are treated every year. Ninety percent of the treated timber, however, is composed of railroad ties, expressed in volume of wood.

This industry obviously, then, consumes enormous amounts of chemical preservatives. The favorite all-round chemical is creosote oil, a product of the distillation of either coal or wood tars.

The measure of a good preservative may be summed up as follows:

1. It must be available and reasonably cheap.
2. It must be antiseptic and poisonous to wood-decaying fungi.
3. It must not readily evaporate or leach out of the wood fibers.

Principal Methods

The methods pursued in wood preservation may be classified as follows:

1. Pressure or cylinder processes.
2. Open-tank process.
3. Brush treatment.

The impregnation of wood by injecting chemical preservatives into the wood under pressure in large cylinders is the method used with ties, paving blocks, and to some extent with other forms of timber. It is therefore by far the most important method. The open-tank treatment is used with poles and posts, usually for treating that portion most subject to decay. The brush treatment is largely applied to shingles, posts, poles, and farm timbers and is relatively of little importance.

Pressure or Cylinder Process. There are a great many variations of the pressure process, depending largely on the preservative used, its adaptability to the species treated, the penetration desired, etc. Many of the variations have been patented and are known by trade names.

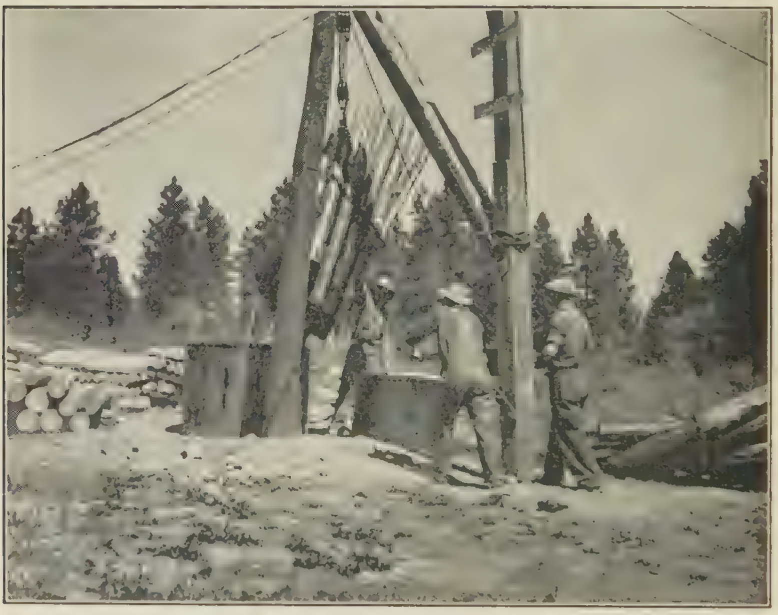

FIG. 118.—An open tank-treating plant to increase the life of thousands of fence posts used in connection with National Forest operations, such as drift fences for controlling grazing, ranger stations, corals, etc.

The principal and most common method followed, however, is the Bethell or Burnettizing process. When used with creosote, it is called the Bethell process; with zinc chloride, it is called the Burnettizing process. The following is a brief description of the method.

The timber to be treated, usually ties, is first seasoned for three to ten months. It is placed on iron trucks, called "cylinder buggies," and pushed on the tracks from the yards directly into huge horizontal cylinders about 6′ to 8′ in diameter and as much as 150′ in length. These cylinders are constructed to withstand high pressure and the heavy doors are hermetically sealed. At first live steam is introduced into the cylinder and a pressure of about 20 pounds per square inch maintained for several hours, depending on the species, its size, and the moisture content. This steaming softens the wood fibers and opens up the pores in the wood. The steam is then led off and a vacuum applied. This exhausts the air in both the cylinder and the wood structure itself and prepares the way for the penetration of the preservative fluid. The vacuum is maintained for about one-half hour, after which, without reducing the vacuum pressure, the preservative, either creosote or zinc chloride, is run into the cylinder at a temperature of from 170° to 190° F. and pressure pumps are employed to force the fluid into the wood fibers. The amount of fluid injected depends upon the species and the amount desired in the tie. The pressure is then released and, in some cases, a vacuum is again applied to draw out the excess fluid and hasten the drying process. The ties are then drawn out of the cylinder on the trucks and piled in the yards to dry out until wanted in the tracks.

The Rueping, Card, Lowry, and other more or less important processes are in common use; but they are all variations of the same pressure treatment.

The following table, published by the Forest Service, illustrates the longer life of the treated railway ties as compared with untreated ties.

Estimated Life of Untreated and Treated Ties

Species	Untreated, life in years	Treated with 10 pounds of creosote per cubic foot, years	Treated with 0.5 pound of zinc chloride per cubic foot, years
Longleaf pine	7	20	(not used)
Chestnut	7	14	11
Douglas fir	6	15	11
Spruce	6	14	11
Ponderosa pine	5	17	12
White pine	5	14	10
Lodgepole pine	5	16	11
Tamarack and hemlock	5	15	11
Red oaks and beech	4	20	12
Maple	4	18	12
Gum	3	16	11
Loblolly pine	3	15	10

Such naturally durable woods as black locust, redwood, cedar, cypress, and white oaks are not shown in the above table because they will last under average conditions for eight to twenty years and are therefore seldom treated. All the above estimates are based on the use of tie plates in the maintenance of the railway track.

The cost of treating ties varies with the method used, the species, character of the heart and sapwood, and degree of penetration. With some species both heart and sapwood are easily saturated with a full penetration; with others, only the sap can be successfully treated.

The cost of treating with creosote is usually about twice that of treating with zinc chloride, but the extra cost is evidently justified by the extra service of creosoted ties in the long run. For instance, with maple, using the above tabulated figures, the cost of creosote treatment is 37 cents per tie and of zinc chloride only 17 cents; but the annual saving over untreated ties is 0.136 cent per tie with creosote as against 0.126 for zinc chloride, taking into consideration the original cost, as well as the cost of treating the ties. Zinc chloride, however, is highly successful in dry regions where this preservative does not leach out.

Open-tank Process. The open-tank treatment is used mostly with posts and poles. Farmers and users of electric light and telephone poles are finding that the prices of the more durable species are advancing so rapidly that they are turning to the use of perishable or inferior species and getting very sattisfactory returns by a simple and cheap preservative treatment.

The open-tank process is used almost entirely with creosote and the following method is usually pursued. The bark is first removed and the wood thoroughly seasoned. This seasoning process, to a considerable extent, replaces with air the moisture in the wood cells. The posts or poles, or that portion to be treated (usually a distance slightly in excess of its depth in the ground) is immersed in a hot bath of creosote up to a temperature not exceeding 215° F. This heating process lasts for two to six hours, depending on the species and their size. During the heating the moisture and air in the wood expand and a good portion of them passes out, appearing as steam or little air bubbles at the surface. The posts or poles are then hurriedly removed to a cold bath of creosote and the contraction of the air and moisture in the wood, due to the cold, creates a partial vacuum, which is destroyed by the entrance of the preservative fluid.

In this way atmospheric pressure, due to change in temperature, accomplishes the impregnation which is secured to a much greater degree in the large cylinders by artificial pressure.

Inasmuch as sapwood is more readily subject to treatment than heartwood, owing to its peculiar structural and chemical properties, species with a large percentage of sap and timbers in the round are treated much more easily than when split.

The open-tank treatment is usually carried out in a very simple and cheap way. It is especially adapted for the use of farmers, or groups of farmers who can use one centrally located plant. It usually consists of a galvanized iron tank or container over a bricked-up oven. A fire is built in the oven for heating purposes and a smokestack is erected to carry off the smoke and create a draft. As about 500,000,000 new fence posts and 3,500,000 poles are used every year in this country, it is becoming an important matter to prolong the life of these timbers.

The cost of treatment per post is from 4 to 12 cents apiece, including cost of equipment. The cost of treating poles is about $1.50 apiece for the average pole. The results from this treatment are certainly more than justified. The average increased life of the treated post is fourteen years and of the pole about ten years.

Many of the most durable species are not treated, especially when used for posts. Among these may be mentioned osage orange, red cedar, black locust, mulberry, catalpa, and occasionally white oak and white cedar.

The following tables, taken partly from the Forest Service, illustrate the estimated increased life, in years, to be expected from treated posts and poles of a few typical species:

Posts

Species	Untreated, life in years	Treated, life in years	Increased life as result of treatment
Longleaf pine	8	20	12
Douglas fir	7	20	13
Red oak	5	20	15
Tamarack	5	20	15
Chestnut	10	20	10

But perhaps the greatest economy can be effected with the use of such perishable and cheap post material as cottonwood, elm, maple, birch, beech, willow, and poplar, which can be made to last from fifteen to eighteen years instead of from three to five years.

Brush Treatment. The brush treatment is a very cheap, but less efficient method of prolonging the life of certain timbers, especially those exposed to the weather, or even poles and posts when the open-tank treatment cannot be used.

POLES

Species	Untreated, life in years	Treated, life in years	Increased life as result of treatment
Chestnut	8–10	20	10–12
Lodgepole pine	5	20	15
Ponderosa pine	6	25	19
White oak	8	20	12
Douglas fir	8	20	12

There are several patent preservatives on the market which are very good. Any of these, or creosote applied hot and in at least two coats, gives fairly satisfactory results. The ordinary paint brush is used to apply the preservative. Although this is only a superficial treatment, the object should be to fill thoroughly and cover with the fluid all cracks, checks, knot holes, or similar defects which offer the best opening for the wood-destroying fungi to work in. All wood should be thoroughly air-dried before the liquid is applied. Dipping is really a form of the brush treatment and gives excellent results with shingles, posts, and sills.

Results of Wood Preservative Treatment

The following table presents a summary of the results that may be expected from wood preservative applied to the principal timbers by the method most effective for each sort of timber.

Class	Life untreated, years	Life treated, years	Average cost of treatment	Increased life in years
Ties	7	17	$0.50	10
Poles	13	23¼	1.50	10¼
Posts	8	22	0.10	14
Piles	3½	21½	0.25 (per cu. ft.)	18
Mine props	3	13	0.11	10
Lumber	18	32	10.00 (per 1000 b. f.)	14
Shingles	8	20	.....	12

CHAPTER XV

FOREST MANAGEMENT AND SUSTAINED YIELD POLICIES

Forest Management — Scope and Objectives

Forest Management is the practical application of the principles of forestry to a given area of timberland. It is the conduct of a forest tract as a business to produce the desired results in the shortest length of time and with the least expense. Forest management is the means of putting technical knowledge regarding trees and their habits of growth into practical effect.

Although the principal objective is wood production and the principle of a profitable enterprise is the paramount theme, the objectives of forest management may include range, wildlife, recreation, or other forms of management. Thus, the single-purpose objective of wood production may be paramount, or the multiple-purpose management may include two or more of these objectives. Timber production is still the central theme of American forest management, but so many other objectives closely integrated with timber production have developed within recent years that the scope has been greatly broadened.

The principle of sustained yield has become widely discussed in forestry circles, especially in the last decade, largely influenced by David T. Mason, William B. Greeley, Austin Cary, W. W. Ashe, and other outstanding leaders.

Land use as a basic principle of land management has also been widely discussed. Since agriculture has been overexpanded, many areas have been selected for intensive development for agriculture, grazing, timber growing, recreational uses, wildlife development, etc. Careful inventories are being made to determine the best uses to which our various types of land may be put. Much of our timberlands must be left as so-called protection forests at the higher altitudes where they may never be cut for timber production. Much waste land and abandoned farmland are being allocated to park and recreational purposes, wildlife management, or for reforestation.

Sustained Yield

Briefly summarized, sustained yield means that the amount cut on a given forest is equivalent to the current growth; expressed otherwise, it means that the amount harvested equals the production. This growth may be an annual or a periodic growth and may be cut by types or compartments, so that the forest capital, or growing capacity, is never impaired or destroyed. Sustained yield means that a balance is maintained between the volume of wood grown and the quantity harvested; thus production and use are equalized, and a permanent supply of raw material is thereby furnished the wood-using industries.

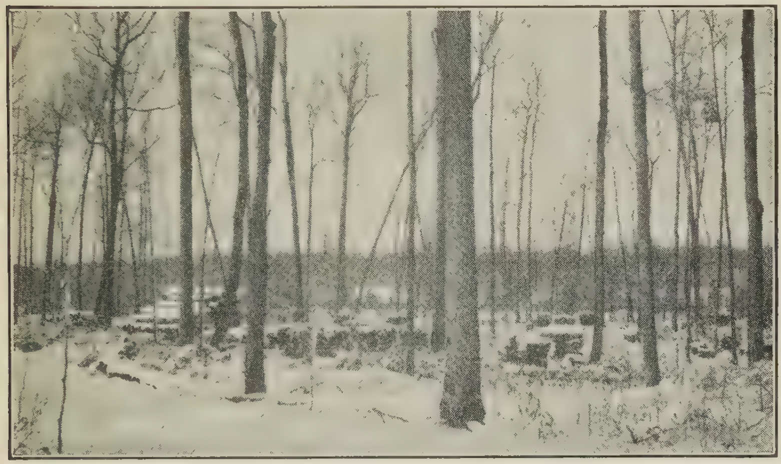

FIG. 119.—An experimental forest of the U. S. Forest Service at Dukes, Michigan, cut under a system of sustained yield by selective logging. The saw logs are ready for hauling to the sawmill, and the smaller wood is stacked and piled ready for transportation to a wood chemical plant.

The unit of sustained yield may be a single forest supplying one industry or it may be a separate drainage basin involving several thousand acres and supplying wood for a group of industries. It may equally apply to an entire region and eventually to the entire country; thus production and utilization may be in complete harmony and balance.

Sustained yield is the very essence of forest management. It involves the continuance of growth and provision for future yield when a timbered area is cut. It implies that the normal growth of timber and the development of wood-using industries dependent upon this growth are approximately equivalent. Furthermore, the industrial capacity should be no greater than the capacity of the forest to provide adequate and continuing supplies. Industrial capacity, furthermore, should not exceed the consumptive capacity. The over-development of industrial capacity has resulted in serious economic and social wastage in many parts of the country. The most notable illustration of maladjustment of this kind is found in the Pacific Northwest, where the sawmill capacity is several times greater than either the growth capacity of the timber in this region or the markets which are or may be developed for these industries. Thus sustained yield is intimately related to employment and economic stability.

In the conversion of 1,000,000 cubic feet (approximately 6,000,000 b. f.) of standing timber on a given tract from saw logs to lumber, 75 men were annually employed and an estimated $75,000 was paid in wages. The resultant products, after manufacture and distribution to destination, were valued at $250,000. If this tract is capable of producing 1,000,000 cubic feet in perpetuity, there will be a balance of timber supply and payroll. Thus the people dependent upon this payroll for their livelihood will continue to live prosperously, and, in the final analysis, this is the very essence and ultimate objective of all sustained-yield plans.

Conditions may eventually develop in this country similar to conditions in Europe where intensive forms of forestry are practiced and where timber growth is approximately equivalent to the timber outlets through local industries. In Europe, there are large numbers of relatively small sawmills, furniture factories, cross tie and timber-treating plants, toy factories, and other industries which are operated continuously upon the annual products of the forests tributary to them.

In the American pulp and paper industry the equivalent of about 12,000,000 cords of pulpwood are used annually. About 7,000,000 cords are imported. These imported goods mean loss of jobs for the equivalent of 70,000 American citizens who could be employed in logging the forests, manufacturing the products, and transporting them to destination. We shall probably see more and more domestic wood used for pulp and paper manufacture as this wood is available in adequate quantities, both in the vast pineries of the South and in the big timber forests of the Pacific Northwest. Enough material is ordinarily wasted during logging in the woods and at the sawmills to keep the entire pulp and paper industry supplied for many years to come. The pulp industry in the Northwest, however, is too remote from centers of consumption to centralize the industry for national production in that one section.

Examples of the application of sustained yield are found in some small hardwood plants in the White Mountains of New Hampshire which use timber from naturally tributary drainage basins in the White Mountain National Forest. The continued growth of timber in these areas and the resultant forest products will keep these small industries permanently supplied with raw materials. Consequently, permanent payrolls are assured to the community, livelihood is stabilized, and the future welfare assured.

There is also an excellent example of the possibilities of sustained yield in Gray's Harbor region of Washington where the industries of Hoquiam and Aberdeen are dependent on the forests in that general region and especially in the southern part of the Olympic Peninsula. It is important and vitally necessary for the economic welfare of these communities that a continuous growth of timber be maintained and a supply of logs and wood products assured for the sawmills, veneer plants, pulp mills, and other industries located in these communities.

The first step toward a plan of sustained-yield management must be made through a study of the possibilities of growth and of industrial outlets in a given region. National, state, and privately owned timber may all be involved in a given location or region. Frequently lumbermen operate on both privately and federally owned timber. It is important that no more plants be installed than can economically consume the annual growth of these properties.

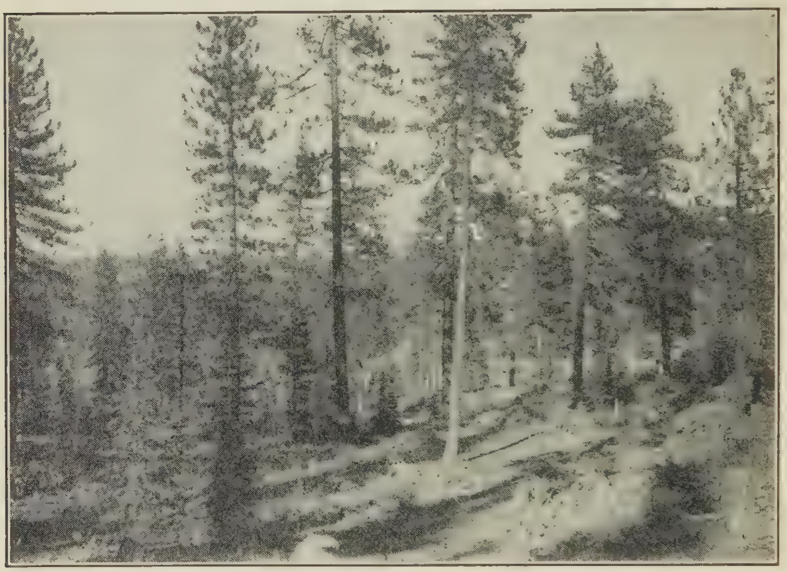

FIG. 120.—A timber sale area on a National Forest selectively logged of the larger and mature trees and where the thrifty, rapidly grown trees are left for more rapid growth and seed production. They will be ready for cuttings in another 40 years. This shows close utilization by low stumps; brush is carefully piled and burned; and the little trees are carefully protected for the future. Plumas National Forest, California.

Sustained-yield management is the underlying principle guiding the policies of our National Forests. It represents the highest achievement possible under forest management. Many state forests have management plans based upon sustained yield, and several outstanding demonstration forests are maintained on this basis; such, for example, as the Harvard, Mont Alto, Duke, Cloquet, Bates, Yale, Arnot, and the Pack Demonstration Forests which have been referred to elsewhere.

Rotation

Rotation is the time which elapses between the formation and the cutting of a wood crop. Generally it means the extension of time between the starting of a forest and its final logging. When a forest is regenerated naturally, rotation usually means the period from the time when the woodland is cut over until the next crop is ripe for cutting.

In all management plans, a definite rotation is determined for the various species or types where a combination of species is found. The rotation depends upon the form of management, that is, the object of the business of growing trees. These objectives may be for the production of sawlogs or for hardwood distillation, the production of box boards, cross ties, piling, and posts, or other forms. One of the most profitable rotations is found in central Italy, where sprout or coppice chestnut is managed on a 15-year rotation. Pulpwood rotations are often from 30 to 60 years. Sawlog rotations may vary from 40 to 60 years for white pine, loblolly pine, Douglas fir, and other quick growing species, to 100–300 years or more for western white pine, ponderosa pine, sugar pine, oak, etc. For cross ties, rotations may be for periods from 30 to 70 years. Redwood has produced saw logs in 30–60 years, especially from redwood sprouts. One plot in second-growth redwoods produced about 130,000 b. f. per acre in a period of about 63 years. This is one of the most rapidly growing demonstrations to be found in the country.

Rotations may be expressed as financial rotations, whereby the trees should be cut at the time they are financially mature; or there may be physical rotations, in which the trees are cut when they are physically mature. There are many complex and involved calculations for the various forms of financial, technical, and physical rotations.

The Normal Forest

A normal forest is a forest under technical management. It is one which is expected to produce the maximum results under the local conditions. It is one in which a calculated annual or periodic yield may be obtained after the rotation has been fixed under a system of sustained annual yield. Management of the forest is laid out in a series of age gradations, whereby a part of the forest is cut over each year or at regular intervals. For example, under 100-year rotations the forest may be divided into 100 divisions or gradations, each one being cut serially. Thus there would be a cutting every year, and at the end of the rotation of 100 years, the area cut off first would be ready for cutting again. This is the very essence of regulated forest management. If the rotation of a coppice or sprout forest is to be 20 years as it frequently is in New York and Pennsylvania for acid wood used in hardwood distillation, there is a cutting every 20 years, at the end of which rotation the forest is ready to be cut again. At least three rotations have been cut in this way, particularly in the southeastern New York counties and in northern Pennsylvania where the sprouting capacity of beech, birch, and maple does not seem to have been impoverished by these repeated cuttings.

The normal forest is the ideal or most efficient forest—one that is fully stocked and producing continuously the maximum possible volume of wood. It may be contrasted with the unregulated forest which is left to nature, wherein growth is slow and unsatisfactory, stands are not fully stocked, and the quality of the product is inferior.

Working Plans Based on Surveys

The management or working plan sets forth the objectives of forest management and the methods that must be followed to obtain these objectives. Generally, the object of a plan is to secure as high financial returns as possible in providing wood for local or regional industries. The objectives, however, may also include maximum provisions for grazing, recreation through hunting and fishing or camping, and other phases of vacationing, the development of summer-home sites, etc.

Before a working plan can be formulated, intensive surveys must be made to determine many facts. Among them are the name and location of the forest, its area and boundaries, past history and treatment of the forest, legal position of the owner with reference to rights, privileges and limitations that may exist on or underneath the soil, the climate, rock formation, and soil history, which may have a bearing upon the conduct of forest management. Some of the principal data to be obtained are the markets for the production of the forest, existing channels or outlets for merchandising its products, probable prices to be obtained for the various classes of produce, methods of logging and of log transport to sawmills, together with the manufacturing and conversion processes necessary to efficient harvesting. Profitable utilization of the product of a well-managed forest is generally considered the " bottle neck " through which the entire plan may succeed or fail. Then, too, the management plan must include a general description of the forest, rate of growth, forest types, injuries to which the trees may be susceptible, and ways of avoiding these injuries. It also includes making of volume tables and yield tables, and the organization of the staff necessary to handle the work. A considerable amount of thought and care must be devoted to the preparation of a management plan. How the plan may best fit the local requirements of industry and community life is becoming more and more important in the development of American forestry. Well-trained foresters must be employed for the survey and the preparation of data for the management plan. Extensive studies of the present stand, its rate of growth, prospective yields, protection from fire and other injurious influences, and of other conditions must be carefully conducted. A management plan is generally made for each one of our National Forests. Very careful plans have been made for many state forests. Perhaps the most extensive and exhaustive studies have been made for some of the demonstration forests, such as the Harvard Forest at Petersham, Massachusetts, Bates Forest in Maine, Pack Forests in Washington and New York, Black Rock Forest in New York, Cloquet Forest in Minnesota, and Duke Forest in North Carolina. Most of the Federal Forest Experiment Stations have experimental forests within National Forests where careful management plans guide the research and other activities.

Measures to Accomplish Better Forestry Practices

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The intensity with which forestry may be practiced for wood production depends upon economic conditions which have been described elsewhere. The objectives of forestry may vary in the different regions. Our forests have generally been mistreated during lumbering and need the adoption of certain measures to put them in normal growing condition. Hence, most of our forests need treatment to reconstruct or assist them to maintain ideal growing conditions.

For the first time in the development of American forestry, large numbers of men in the Civilian Conservation Corps have been available to do the work of the woods. With this great body of man-power many things have been accomplished which foresters have awaited for years. There are usually 350,000 young men available in these camps, located as a rule on public forest property, that is, state and federal forests and parks.

The following measures include those which are necessary to put our forests in better growing condition for wood production and utilization.

1. **Thinning, Weeding, Girdling, and Pruning.** Nearly every young and immature stand of timber requires thinning, weeding, girdling, or pruning. Undesirable species must be removed at the right age. Crown and root competition must be kept in proper balance. In hardwood stands, weedings may greatly benefit the stand when it is from 5 to 7 years of age. In the spruce-hardwood types and white pine stands, the inferior species and poorer specimens must be culled. Previous

lumbering has often left the poorer species, such as birch, in command, whereas the more valuable spruce, white pine, oak, or maple should be encouraged by judicious weedings or thinnings. In Arkansas, low-valued species are girdled to give the space to the more valuable white oak. Girdling is also done to assist the better trees in southern pine and spruce versus hardwoods in the northern forests. Girdling costs only about $2.00 an acre. The Finch-Pruyn Company has girdled worthless hardwoods during the past five years to encourage the valuable spruce for pulpwood in the Adirondack region. Thinnings in the sapling and pole stages of development stimulate rapidity of growth and improve the quality of the product. Near Fargo, Georgia, over 2500 acres of 15 to 25 year old longleaf and slash pine have been thinned, reducing the stand of 600 to 1200 trees per acre to 250, at a cost of about 50 cents per acre. Pruning is generally done for one log length to produce higher grade lumber by removing knots (limbs). Pruning has increased the value of trees by $35 per m. b. f. in New Hampshire.

2. **Selective Logging.** This is really an American system of silviculture to provide for present profits as well as for continuous growth and adequate future yield. It may be applied to both virgin and mature second-growth timber. It is also applicable to a selective or any-aged type of forest. Where intensive utilization and profitable marketing may be employed, selective cutting is most successful. Trees are selected and marked for cutting to fixed or flexible diameter limits. Detailed studies have been made in all the important forest types and regions by the United States Forest Service to determine these diameter limits.

For example, near Marquette, Michigan, in a hardwood stand of 6350 b. f. per acre, with 190 trees per acre more than three inches in diameter, by selective cutting only trees 22 inches or more in diameter were taken. This meant that, with only 8 trees per acre marked for cutting, 2250 b. f. per acre, or 35% of the original stand, were produced. About 8 cords per acre of chemical wood for hardwood distillation was obtained with a stumpage value of 50 cents per cord. By motor-truck logging, with its flexible sources of supply, smaller amounts per acre were profitably logged than might have been logged with other expensive forms of transportation, such as logging railroads, power skidding, etc. The cost of logging was only $10.50 per m. b. f. These logs produced an average of $28.93 per m. b. f. contrasted with $19 for logs cut in the ordinary way The residual stand contained 41 trees per acre between 12 and 22 inches in diameter; and another cut of equal volume and perhaps increased value may be made in about 20 years. Thus the average annual return per acre, not including interest or other charges, will be about $2.50 per year.

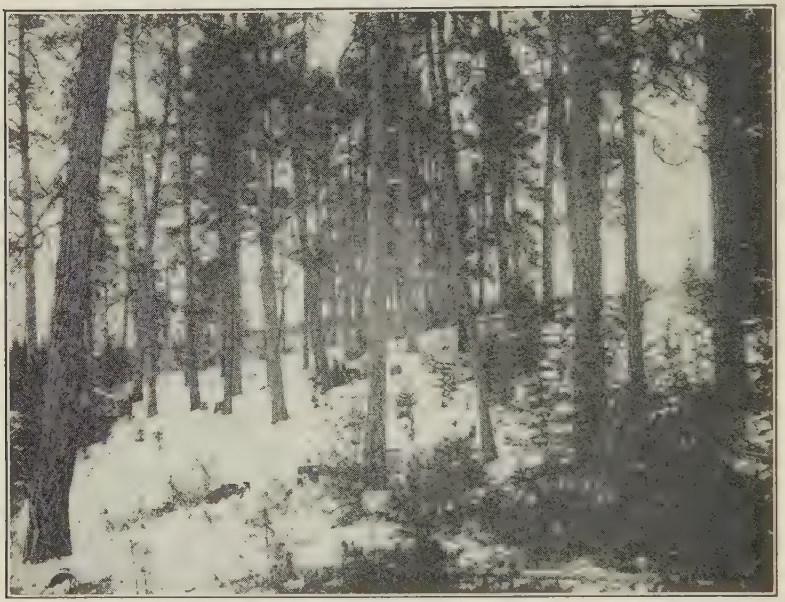

FIG. 121.—View of ponderosa pine timber showing results of reproduction twenty years after area was carefully logged by horse skidding. Young timber left after selective logging has greatly increased growth as a result of crown thinning. Western Montana.

In selective logging in Sitka spruce — western hemlock in Oregon — a net return of $1.26 per m. b. f. higher than the ordinary clear-cutting method was obtained.

3. **Preventing the Cutting of Young and Rapidly Growing Trees.** Too frequently young and rapidly growing trees are cut before they are financially mature. In many parts of the South and East, a tree only large enough to produce a 2″ × 4″ dimension stick is cut. Too frequently trees which will yield a 1″ × 6″ board or a 6″ × 8″ tie is cut. In many stands no cutting should be done at all. Frequently the trees are well spaced and in good growing condition and require neither thinning nor other forms of cutting to grow to maturity and produce the most profitable products. The great contrast between ordinary logging and selective logging is that only profitable trees are cut by the latter method. Therefore, the most wise and profitable method from a long-time viewpoint is to leave the young growing trees until they reach a merchantable and profitable size.

4. **Reforestation.** Planting constitutes a most intensive and best form of forestry in those regions where, as a result of fire, lumbering, or other forms of denudation, nature is not restoring trees on the areas and they must be planted. Many abandoned farms require planting. Badly eroded slopes and hills require planting. Occasionally underplanting is necessary where the present stand is not sufficiently dense or properly occupying the growth space. In California, sprouts from redwood stumps are sufficient to restock only a portion of the area. Additional restocking by planting is necessary. In many regions of the South, the areas, after logging, are not springing up to natural growth and must be planted. Within four years since 1933 about one billion trees have been planted by the Civilian Conservation Corps. This is only a small start compared with what we should do to restock our forest areas by planting. In such states as Pennsylvania and New York notable progress has been made in reforestation. Generally conifers are preferred to hardwoods because the conifers are more rapid growing, they will grow more trees to the acre, they are more valuable when mature, and they are relatively free from insect and disease attack.

5. **Protection Against Fire, and Insect and Disease Attack.** It is obvious that any plans for intensive forestry are

worthless without adequate protection from fire and other injuries. Fire protection is a prerequisite in all plans for forestry, as explained more fully elsewhere in the book. Sometimes over-grazing by live stock, the ravages of deer on sprouts, and seedlings damaged by rabbits or porcupines have resulted in serious injury both to planted and natural forests.

6. **More Complete Utilization.** Only about one-third of the wood volume of trees felled in our woods is used. The major portion is wasted in the form of bark, tops, stumps, and limbs in the woods and sawdust from the saw kerf, edgings, and trimmings at the mill. Under improved forestry practices much of this can or will be utilized. Economic conditions largely determine the results to be secured. There must be a profit motive to utilize the immense wastage now prevalent in converting our trees to useful forms of lumber and other materials for mankind. One-third of the Pacific Northwest timber felled in the last 10 years has been converted into lumber, etc. at a financial loss. Economic selective logging is very helpful in preventing this great wastage and financial loss. The upbuilding and maintenance of permanent wood-using industries, the use of new processes, and increase in the efficiency and improved methods of small sawmills will help in more complete utilization. New methods of chemical conversion, improved fuels, and other products are constantly being devised. In Europe, some motor cars are operated by wood gases. Cattle food is being developed from waste in Germany. There are large possibilities for improved utilization in this country. Research has been of great assistance and is likely to be more helpful in the future.

7. **Improved Methods of Transportation.** Forest roads have been called the arteries of successful forestry practice. Thinnings, saw logs, and other products cannot be profitably sold without cheap transportation. Fire protection, the bringing in of men, and tools and plants for reforestation are made possible by good highways. In Europe, forest roads are usually permanent so that logs, salvage cuttings, thinnings, etc.

may be moved to market at a minimum of expense. Good permanent roads mean that a small volume of wood per acre may be removed at intervals, without increased expense. On the National Forests, good highways have converted worthless or low-value stumpage into high-value stumpage. Thus worthless standing timber has been made marketable. The men of the Civilian Conservation Corps have been of great assistance in building thousands of miles of forest roads in all of the forest regions.

8. **Improved Logging Devices.** The improved tractor and motor truck are of great assistance in the practice of more intensive forms of forestry by lowering logging costs and, particularly, in the flexibility of operations. The tractor can be used in many different ways, as hauling out logs from the forest, hauling in men, food, and supplies, in fire protection, reforestation, road building, powering small sawmills, and in many other ways. The motor truck on our improved highways has provided a wide source of log supply for our sawmills and has made possible the taking out of only a few of the bigger and better trees rather than the clear-cutting of entire stands. Both tractors and trucks, by helping to lower logging costs have increased stumpage values and, therefore, opportunities for more and better forestry in the woods. If foresters can lower logging costs, they will thereby directly increase stumpage values and, in turn, provide an opportunity for more intensive forestry practices in the woods.

9. **Leaving Seed Trees for Natural Reforestation.** In many sections of the country favorable conditions of soil and precipitation, and trees from which seeds are scattered naturally and easily by the wind mean that forests are quickly and easily reproduced. If in cutting the forest, two to eight or more evenly distributed seed trees per acre are left for reseeding, the forest will naturally come back quickly and with desirable species. Nature has already provided seed trees in our woods so that there has been a constant succession of plant life. Unfortunately the natural reseeding comes sometimes from

slow-growing, low-value, or other undesirable trees. In many stands, however, the leaving of seed trees is the keynote to a successful renewal of the stand for future crops.

It must be understood that a combination of two or more, or perhaps all, of these nine measures may be essential on a given tract. This depends on local conditions. Protection from fire and other injurious agencies is the first prerequisite in all plans of management. If freedom from fire is assured, there may be no necessity for planting little trees or leaving mother trees to reseed the area. In the mountains of southern California fire protection is vital and all-important. Measures other than reforestation may not be advisable. In the southern pineries, selective logging and leaving seed trees may be vital, together with fire protection to insure better forestry practice. In the dense hardwood and hardwood-softwood stands of New England and the Northeast, thinning, weeding, and girdling may be very necessary. In most of the virgin and mature

FIG. 122.—The maintenance of the navigability of our streams in the East was the reason for the purchase of large areas of eastern National Forests. This shows well-timbered slopes on Cold Mountain in the Pisgah National Forest near Asheville, North Carolina.

stands, selective logging and fire protection may be the sole requirements. In most of the woodlots throughout the Northeast and South, there is entirely too much cutting of young and immature trees which are at the zenith of their most rapid growing period. Better logging methods and devices are needed in all parts of the country where good-sized stands are present and are about to be logged.

CHAPTER XVI

EXAMPLES OF FEDERAL, STATE, INDUSTRIAL, FARM, AND ESTATE FORESTRY

The following are very brief sketches of typical examples of the practice of forestry by federal, state, and private agencies in various parts of the country. There are two examples of National Forests, one of State Forests, five of industrial forestry, one of farm woodlands, and one of estate management.

Siskiyou National Forest, Oregon. This forest, with supervisor's headquarters at Eugene, derives its name from a tribe of Oregon Indians. It contains a gross area of over 750,000 acres along the summit of the coast range and the Pacific Coast line from Tillamook Bay to Coos Bay for about 40 miles north and south, extending from 30 to 40 miles inland from the ocean. The growing of timber crops, with adequate provision for recreation, are of major importance on this forest. There is very little water power development and practically no livestock grazing. This is one of the most important and productive regions for raising timber because of the long, relatively warm, growing season, abundant precipitation, and favorable soil qualities. Although this area has been heavily and repeatedly burned at times, there are now about 6 billion b. f. of timber remaining from the original 25 billion b. f. Only about one billion is immediately merchantable and available for timber sales. The principal species in order of importance are: Douglas fir, western hemlock, Sitka spruce, and western red cedar. Port Orford cedar also grows in this section and is a very important tree of the future. It is sought by Japanese builders because of its enduring qualities and resists attacks of ants which destroy other kinds of wood. Some of this timber near Marshfield has been sold for $25 per m. b. f. on the stump, which is one of the highest values found anywhere in the country.

Clear logs for export have commanded a price of $50 per m. b. f. delivered at the mill.

Timber grows rapidly as shown in the following figures: A sample area at 60 years of age showed 229 trees per acre averaging 109′ in height, 14.2″ in diameter; produced timber at the rate of 808 b. f. per acre per annum; and for a period of the last 10 years grew at the rate of 1575 b. f. per acre per annum. An important reforestation project on Mount Hebo has resulted in the successful planting of over 10,000 acres of Douglas fir. Experiments with eastern hardwoods have not been successful because of the competition from native vegetation, and eastern and exotic softwoods do not grow as rapidly as Douglas fir. There are abundant opportunities for camping, fishing, and hunting; and each year numerous rivers, lakes, and streams flowing to the ocean are in active service. There are also many deer, bear, and wild cat, and the streams provide salmon and trout. Even good surf bathing is provided along the beaches.

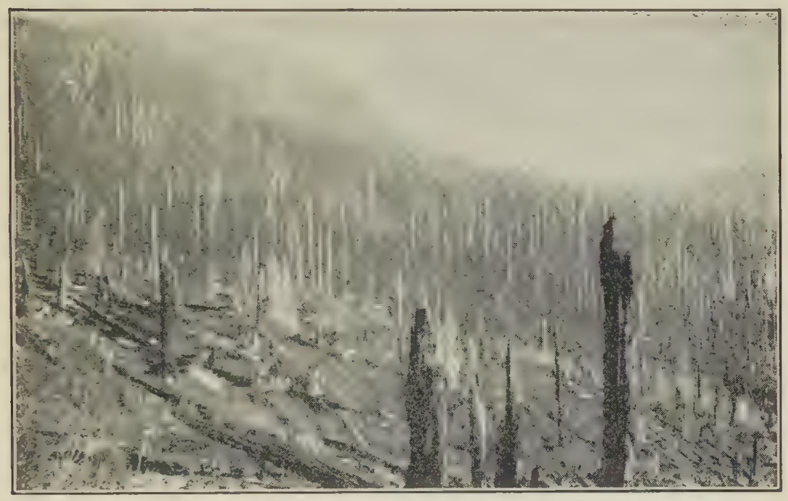

Fig. 123.—Thousands of snags (dead fire-killed trees) on the south slope of Mount Hebo in Oregon. This area is being planted and is one of the big reforestation projects on the Pacific Coast.

White Mountain National Forest, New Hampshire. This forest contains about 1½ billion b. f. of merchantable hardwoods, chiefly maple, birch, and beech, and smaller quantities of red spruce, hemlock, and white pine. It is capable of producing about 60 million b. f. of forest products yearly on a sustained-yield basis. Under complete protection and efficient management, the productive condition of the forest may be steadily improved by the utilization of more products. The growth far exceeds the cut at the present time. The important object of management is to increase the sales so that the cut equals the annual growth. These forest products play an important part in supplying the timber needs of New England and immediate adjacent territory without lessening its important recreational and scenic values. The establishment on a permanent basis of diversified industries promotes both the economic and social welfare of the region as a whole, as the Forest is within a short distance of growing and important marketing centers served by rail, highway, and water systems of transportation. The outstanding topographic feature is the Presidential Range, including Mount Washington, which rises to a height of 5692′, and many adjacent peaks. More than two-thirds of the partly forested upper slope areas are not in the National

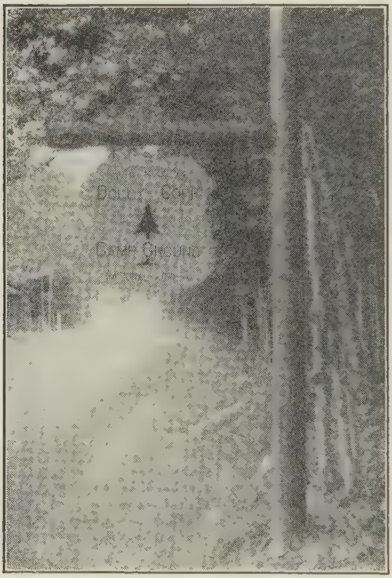

Fig. 124.—A well-located entrance to the Dolly Copp camp ground and recreational area in the White Mountain National Forest in New Hampshire. Excellent facilities are provided the public for camping, picnicking, hiking, and other forms of recreation in our National Forests and Parks.

Forest, but there are still many private holdings interspersed within the exterior boundaries. The protection of lands for stream-flow regulation and scenic attractiveness are important features of forest management as well as timber production. Recreation is recognized as a resource to be developed in every way, concurrently with the growing of timber and the protection of watersheds. This superb recreational center is featured by some notable scenic panoramas and wonders of nature, such as Franconia Notch, with the " Old Man of the Mountain," " The Flume," a great crevice in solid rock 900′ long and about 60′ to 70′ deep, as well as several such unique rock formations and beautiful waterfalls as Glen Ellis and the Crystal Cascades.

Thus there is a balanced plan of forest management, including timber production, recreation, and watershed protection. Sustained-yield management provides for all these objectives. Many hundred thousand visitors go annually to this area for camping, picnicking, and vacationing.

Mont Alto State Forest, Pennsylvania. This is one of the oldest and best demonstrations of a successfully operating state forest. Established in 1903, it has about 23,000 acres of third-growth mixed hardwood, chiefly oaks (mostly rock oak), birch, and gums, maple, yellow poplar, with some softwoods, such as pitch pine, white pine, shortleaf pine, and hemlock. Formerly, there were abundant stands of chestnut, but the blight has eliminated this species. Some of the best experiments in reforestation date back to 1903. Various forms of improvement thinnings, cuttings, etc., are to be seen. The permanent personnel consists of a district forester, assistant forester, and three forest rangers. The fire-protection system revolves largely around two steel towers among 115 maintained by the state, 11 miles of telephone line, 60 miles of forest truck roads, and 90 miles of forest trails. There are some 17 permanently leased camp sites and excellent facilities for various forms of forest recreation. There are 71 million b. f. or 32 million cubic feet of standing timber. The annual growth is 12,500 cords.

There is a sawmill and shingle mill which are used to convert the products of the forest into salable commodities for local building requirements and industries. A forest tree nursery of 16 acres, established in 1902, has produced over 55,000,000 seedlings and transplants. There is a very complete and interesting forest arboretum for scientific, educational and demonstrational purposes, started in 1903, with most of the native species and 100 species from regions outside Pennsylvania — altogether about 500.

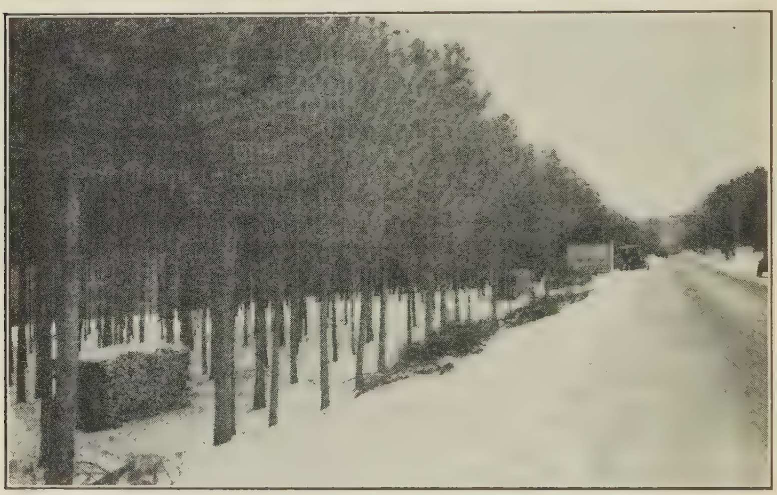

Fig. 125.—Demonstration forest showing proper methods of thinning and pruning a dense stand of white pine along a main highway in Pennsylvania. The thinnings are piled and sold for fuelwood and the brush piled and burned. There are excellent demonstration and experimental tracts on the Mont Alto, Harvard, Yale, California, and Duke forests, two Pack forests in Washington and New York, the Cloquet forest in Minnesota, and elsewhere.

Here are located the Pennsylvania Forest Research Institute, a two-year ranger school, and a building in which students of the Pennsylvania State Forest School are instructed their first year, the remaining instruction being given at State College, Pennsylvania.

Practically all activities typical of eastern state forests are found on this state tract, and here many interesting experiments and examples of successful forest management may be seen, including two well-equipped recreational areas and five game refuges.

There are many excellent examples of the successful practice of private forestry by lumbermen and other private owners in several parts of the country. With a greater stimulus given to the practice of private forestry, sustained yield and selective logging are being put into practice more and more. This is the very essence of successful forest management. The following are typical examples of what lumber companies are doing both for the present and for the future.

1. **Goodman Lumber Company, Goodman, Wisconsin,** has 60,000 acres of mixed hardwood and softwood timberland and about 20,000 acres of cut-over lands in Marinette County, Wisconsin. Operations began in 1903. Logging is done by means of horse skidding and tractors, the logs being moved from the felling area to the logging railroad spurs. Recently trucks have been added, so that horses, tractors, and motor trucks are all used in connection with the logging railroad. Some logs are trucked directly to the mill. The timber is handled on a rotation of 140 years. The chief species are hard maple and yellow birch, with some basswood, elm, and ash among the hardwoods, and hemlock and white pine with some spruce, Norway pine, white spruce, and balsam fir among the softwoods. Aspen or popple occurs predominantly on cut-over and burned areas but finds a good market for pulpwood and excelsior.

For 20 years the company practiced clear cutting. Fires did large damage to reproduction and resulted in the springing up of inferior growth. Until about 1917 some lands were disposed of for farming. Taxes were too great a burden to carry cut-over lands and it became the policy of the company to liquidate its timber as rapidly as its facilities would permit because of economic necessity. In 1927, the state forest crop law changed the entire policy. For a 50-year period the owner is taxed for the timber at 10 cents per acre. The state adds an additional 10 cents per acre and a severance tax of 10% of stumpage value is imposed. Since 1927, the company has been operating on a selective logging basis and has dropped its annual cut from 24 million to 12 million b. f. In selective logging, about one-half of the volume is removed in the first cutting. This includes both over-mature and defective trees and opens the crown cover so that the residual stand may grow more rapidly. It will require 12 years to complete the first cut, and then a second cycle of cutting will begin on the previously selected logging areas. This change in harvesting timber results in increased logging costs but by use of tractors, longer skidding, and winter sled hauls costs are being reduced. The use of motor trucks is also assisting in more economical logging. Three important changes in utilizing the products have resulted favorably for the plan of selective logging.

(1) In 1927 a rotary veneer plant was built for intensive utilization of selected birch and maple logs, which have a high stumpage value for veneer purposes.

(2) In 1931 a hardwood dimension plant was installed for sawing certain types of hardwood logs directly into small pieces of dimension, which are kiln-dried green from the saw and shipped to the fabricator.

(3) A hardwood distillation plant was taken over to use tops, defective and poorly shaped timber, such as wolf trees, and otherwise to utilize more intensively the raw product of the forest.

A very flexible diameter limit is used. Most of the volume of standing timber is in the 18″ and larger diameter classes. This is one of the outstanding examples of successful selective logging.

2. **W. T. Smith Lumber Company, Chapman, Alabama.** This company was founded in 1880, the present McGowin family taking it over in 1905. It is a large producer of shortleaf pine with 160,000 acres of timberland and sustained-yield production annually of 30 million b. f. from two sawmills. There are also three other sawmills. Accurate surveys have

been made to determine rate of growth in board feet per acre per annum, probable future cutting cycles, and a general plan of management for the future. A flexible system of selective logging is followed, with no fixed diameter limit for cutting. Some trees up to 20″–24″ in diameter are left for later cutting; defective trees and those with poor crowns are cut. There are seven modern fire towers connected by telephone and closely coordinated with federal and state forest services. Experience in experimental planting has proved that tree planting is unnecessary because the natural regeneration of the area is sufficient to assure new growth as long as fires are eliminated. Recently this company changed from power skidding in the woods to trucks and tractors for reasons of economy and of assisting reproduction. All trees are marked for cutting by a skilled and experienced woodsman to maintain a proper stand after selective logging.

3. **The Michigan-California Lumber Company, Camino, California,** owns about 80,000 acres of sugar pine and ponderosa pine, Douglas fir, and other firs in the Sierra Nevada Mountains on the American River watershed. The estimated present stand is 1,600,000,000 b. f. of timber; and the operation has been going about 30 years. About 25,000 acres have been cut over to supply a sawmill with a maximum annual cut of 30,000,000′. About 5000 acres have been transferred to the Forest Service and the University of California. This sawmill and logging operation furnishes support for 400 employees and their families. If the growth of this tract is continuous and the supply sufficient, this sawmill will be in existence in perpetuity; and therefore the communities depending on the sawmill and logging operation and distribution of the lumber at Pino Grande and Camino will be permanent. There is virgin timber to last 40 years at the present rate of cutting. In 40 years the successful second-growth stand, if protected, will be ready for cutting. The company cuts and handles its timberland to assure a reasonably well-sustained production. This is accomplished in part by efficient fire-protection system in

cooperation with the Eldorado National Forest, and by the maintenance of fire-fighting trucks and care in logging.

Logging is done by tractors to avoid damage to reproduction and young trees in place of power skidding which was so destructive. Timber fellers are instructed to avoid all possible damage to young growth and trees left uncut. All snags (dead standing trees) within 200′ of the logging and haul roads are felled. All trees 25″ or below in diameter are left during logging. At considerable distance from the landings, trees up to 28″ in diameter are left. Not more than one-quarter of the volume of Douglas fir and white fir is being cut. By this process an adequate number of trees are left for reproduction. Slash is burned in the fall in strips along railroad and truck roads and ridge tops. This slash is generally burned downhill in order to control the fire and it is burned during the autumn. This progressive company is making a sincere effort to handle its extensive holdings on a definitely sustained-yield basis.

4. **T. R. Miller Mill Company, Brewton, Alabama.** About 1925 this company was impressed with the possibilities of sustained-yield management through selective logging and the beneficial results of protection from fire and grazing. Longleaf pine 14″ and up in diameter is turpentined and after three years cut into lumber. Much planting of both longleaf and slash pine has been done since 1930. These plantations have been very successful. Young stands are also being thinned and used for fence posts, pulpwood, and small poles, so that the remaining stand of about 400 to 600 trees per acre is left. Later more trees will be taken out, leaving 200 to 300 trees per acre to form the final stand. The total acreage is about 125,000 and it is estimated that the timber is growing at the rate of 200 to 400 b. f. per acre per annum, which is equivalent to from 25 to 50 million b.f. annual growth on the total acreage. The company maintains a turpentine still, sawmill, timber creosoting plant, and a veneer box factory, which permits excellent utilization in both the woods and at the mills.

5. **Finch, Pruyn and Company, Glens Falls, New York.** This company owns about 174,000 acres in the upper Hudson

River watershed in the Adirondack region of New York. Timber consists of red spruce and balsam fir on the lower slopes near lakes and streams and on the upper slopes of the mountains, producing from 10 to 30 cords per acre. The elevations range from 1700′ to 4500′ above sea level. Hard and soft maple, yellow birch, and beech are found on the rolling land and ridges between the lower and upper slopes. There is some white birch, white ash, and poplar on old burns. The average annual cut is 35,000 cords of peeled 4-foot pulpwood, of which red spruce comprises 80% and balsam fir 20%. It is driven down the Hudson River approximately 100 miles to Glens Falls for conversion into newsprint.

Accurate records of topographic, type, and timber maps are kept and lands classified according to their productivity. Close cooperation is maintained with the state of New York in furnishing fire protection. A private telephone system connects headquarters camps with the five logging camps and with the state fire protection system. During hazardous periods temporary lookouts and special patrols are employed. There is a permanent fire warden. Five portable gasoline-driven fire pumps and several thousand feet of linen hose are maintained, with other fire-fighting equipment, at all camps and strategic points. Small brooks are dammed and water holes blasted out in wet places to supply water for the fire pumps, in addition to the several streams traversing the tract.

During hazardous fire seasons humidity, temperature, precipitation, and other records are taken and studied daily. A definite working plan is followed in cutting spruce to an approximate diameter limit of 8″ to 9″. All trees to be cut are marked and the area subdivided into compartments of from 300 to 1000 cords each. These are the logging units and their boundaries are determined by costs of logging and topographic conditions. Each camp produces about 5000 or more cords of wood yearly and follows a carefully designed logging and cutting plan prepared by the forestry department. During cutting operations care is exercised to protect reproduction and young growth as well as all trees left standing on the tract.

Stumps are cut low, tops are lopped down to 3″, and non-merchantable species used in camp, road, bridge, splash dam, and other forms of construction. Trees are felled and sap peeled during the peeling season, from about May 15 to July 31. During August and September the trees are skidded out to the main haul roads, cut into 4′ lengths, and piled. After January 1 they are sled-hauled over ice and snow roads to landings on lakes and along streams to await spring thaws, when the pulpwood is driven to the mill. About 60 days is required for the drive to reach Glens Falls, and the losses through strayage, etc., are less than 1%.

Girdling of beech and other non-merchantable hardwoods is done to encourage the growth of more desirable softwoods. About 2,000 acres have been girdled. Areas for girdling must be carefully selected and the work carefully done. Girdling is still in the experimental stage. Average annual growth increment is figured at 2.38%.

The duties of the forestry department are to prepare facts, maps, and records for the efficient logging of the tract. Some of these duties are mapping and surveying of all holdings and marking of exterior boundaries, timber estimating, laying out of all logging operations in the woods, and location of camps, haul roads, etc. Foresters mark all timber for cutting and keep in touch with logging as it progresses. Girdling of hardwoods, making reports and estimates on areas for prospective purchase or sale, testing solid-wood contents of stacked cords, studying river-driving losses, inspecting timber holdings and insect and wind damage, inspecting logged areas, revising plans for future use, planning and installing telephone systems, studying the details of fire fighting and control, making growth studies, and keeping timber inventories, all are included within the duties of the foresters.

Farm Woodland Management. Farmers seldom keep any records of expense or income on woodlands. In some parts of the country these operations have proved to be very profitable. Thrifty farmers in Ohio and Indiana have shown how profitable careful management may prove to be under favorable circumstances. According to R. K. Day, some have been excellent examples of employing their own time and their teams for winter cutting and marketing the timber to best financial advantage. One farmer in Indiana received an income of over $10,000 in cash for a period of 13 years from 75 acres of woodlands. This was at the rate of $10.75 per acre gross return. During this time 266,000 b. f. of logs were delivered at a return of $35 per m. b. f., 642 cords of fuelwood were sold at $3.10 per cord, and 25 cords per year were used at home. The woodlot was well stocked and in growing condition for future yields at the end of this period. Farm woodlands sold as stumpage or standing timber bring only a fraction of their real value. When they are converted into saw logs, fuelwood, veneer logs, cross ties, etc., and delivered at a local mill or market, much better values may be realized.

Estate Forestry. Near Hyde Park, in Dutchess County, New York, President Franklin D. Roosevelt has been practicing forestry on about 600 acres of woodland and potential forest land on a farm of 1250 acres. This woodland is a typical series of disconnected second-growth hardwood woodlots, with a small portion of old-growth hemlock and hardwoods on the steep slopes rising about 300′ directly from the Hudson River. Since 1915, a definite plan of management has been pursued. The object is to practice forestry and raise as much wood as possible while preserving the best aesthetic features and providing cover and protection for game. Many experiments have been conducted to try out the best species for planting in the local soils and under local climatic conditions. The forest is composed largely of mixed oak (white, red, rock, swamp white, black, and scarlet) with some hickory, hard and soft maple, beech, black birch, ash, black gum, yellow poplar, cherry, sycamore, hemlock, and white pine of various ages and growing conditions. Formerly there was much chestnut but it has been completely killed by the blight. There is a wide variety of rock ridges, swamps, gentle to steep slopes, and both thin and deep soils. The chief products are fuelwood, for which there is a ready local market, saw logs for local lumber and farm requirements, fence posts, cross ties, poles, and piling. From 50 to 100 cords of fuelwood are cut each year. All trees to be cut are carefully marked. The "wolf" trees, poorly formed, crooked, and inferior species are cut for fuelwood. Mature trees are taken for saw logs and some oak piling and cross ties are cut when the market is attractive. The principal activity, however, is planting trees, over 170,000 having been planted during the past ten years.. The chief species used for reforestation are white pine, red pine, Scotch pine, European and Japanese larch, Norway spruce for Christmas trees, and white cedar for posts. All planting is done on abandoned pastures and fields formerly tilled. Some experimental planting has been tried out with ponderosa pine, Japanese and Sitka spruce, Douglas fir, black walnut, yellow poplar, and red oak. The Heiberg plow has been used for planting on the open fields and some direct seeding of hardwoods has been tried.

PART II

OPPORTUNITIES FOR SERVICE WITH ORGANIZATIONS PRACTICING AND PROMOTING FORESTRY

INTRODUCTION

The opportunities for service have been greatly increased within recent years, because the activities and the very conception of forestry have been broadened materially. Moreover, the outlook for forestry has been greatly improved since 1933, when President Roosevelt inaugurated many new conservation measures, such as the Civilian Conservation Corps, Soil Conservation Service, Plains Shelterbelt Project,* Resettlement Administration, new Grazing Bureau, and Tennessee Valley Authority, which directly or indirectly affect the forest policies of the nation and offer enlarged opportunities for employment of professionally trained foresters. Furthermore, existing agencies, such as the Forest Service and the National Park Service, have been greatly strengthened, expanded and supported.**

According to Graves and Guise, the following table shows the distribution of graduates of forest schools for the period

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*This project, started on July 21, 1934, was liquidated in 1936. At that time, 1277 miles of shelterbelt strips were planted, 6474 acres of farmstead plantings made, over 23 million cuttings and nuts planted, 75 million trees were growing in nurseries and 2660 unsolicited applications for shelterbelt plantings were on file.

**In 1937, President Franklin D. Roosevelt urged reorganization of the entire structure of national government, placing federal conservation matters largely in the Department of Conservation, formerly the Department of the Interior.

1900 to 1909, in which period an occupational study of 1718 graduates was made:

Occupations	Percentage
Forest industries	29.2
U. S. Forest Service	27.4
U. S. Bureaus other than Forest Service	5.9
State service	11.1
County and municipal services	3.0
Educational institutions	9.3
Forestry and trade associations	1.6
Private estates	1.4
Consulting forestry	2.1
Forest nurseries	1.0
Tree and landscape agencies	3.6
Foreign service	1.2
Graduate study	3.2
	100.0

The following chapters are devoted to a brief résumé of the principal services and organizations, both public and private, which employ professionally trained foresters.

CHAPTER XVII

FEDERAL ORGANIZATIONS

U. S. Forest Service

This is the largest, oldest, and most important and effective agency in practicing and promoting forestry in the United States. It is also the most important employer of professionally trained foresters. The federal service was started in 1876, but not until 1891 were the first forest reserves created.

FIG. 126.—Foresters with a pack train hauling in camp supplies, food, and equipment to a wilderness area in Montana. The work may require long and arduous hours spent in primitive conditions far removed from the usual urban comforts and pleasures.

No provision was made for their organization and administration until 1897. In 1905 the Bureau of Forestry in the Department of the Interior was changed to the Forest Service in the Department of Agriculture, under Gifford Pinchot. This change marks the real beginning of actual federal forestry work. Later, in 1907, the forest reserves were known as National Forests—to avoid the popular conception of reservations rather than forests for useful development. The administration of the Forest Service in Washington was decentralized in 1908 and regional offices set up. Each of these headquarters has a regional forester with administrative assistants in charge of the major phases of the work. The regions, locations of headquarters offices, and extent of each region are shown here:

Region	Regional Headquarters	States of Each Region
1.	Missoula, Montana	Montana, northern Idaho, northwestern South Dakota, and northeastern Washington
2.	Denver, Colorado	Colorado, most of Wyoming, southwestern South Dakota, western Oklahoma, and Nebraska
3.	Albuquerque, New Mexico	New Mexico and Arizona below the Colorado River
4.	Ogden, Utah	Utah, Nevada, southern Idaho, northern Arizona, and western Wyoming
5.	San Francisco, California	California and part of western Nevada
6.	Portland, Oregon	Washington (except northeastern corner) and Oregon
7.	Washington, D. C.	The northeastern region, including Virginia and Kentucky
8.	Atlanta, Georgia	South and southeastern region from North Carolina to Texas, Arkansas, and western Oklahoma inclusive
9.	Milwaukee, Wisconsin	The Lake States and Central States, including Ohio, Indiana, Illinois, Missouri, and Iowa
10.	Juneau, Alaska	Southeastern Alaska

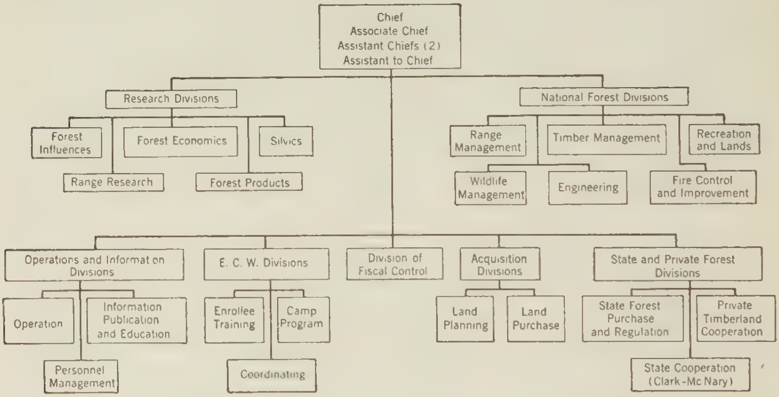

FIG. 127.—Organization chart of the U. S. Forest Service.

Location and Area of the National Forests. They are located largely in the Rocky Mountains and Pacific Coast States, where 134 million out of a total of 170 million acres are found. This was the original development, as most of them were created from the national domain in the so-called public land states. Fourteen million acres are located east of the Great Plains and 21 million in Alaska. The Weeks Law of 1911 provided for purchase of timberlands in the East to protect the navigability of streams. Recently, large purchases have been made in the Lake States and the central, southern, and eastern states for National Forest purposes. The National Forests include about 20 million acres of private or abandoned land within their exterior borders, so the gross area is about 190 million acres. These lands are largely of second-growth and cut-over timber in the East and virgin timber in the West. However, much of it is inaccessible and non-merchantable because it is located at the higher altitudes and generally comprises the less valuable timberland in the West. The forests are of great value, however, for watershed, forage, and recreational purposes as well as for timber production. They are constantly being developed in a more important way for timber production and many in the more accessible locations play an important part in the local and regional timber markets.

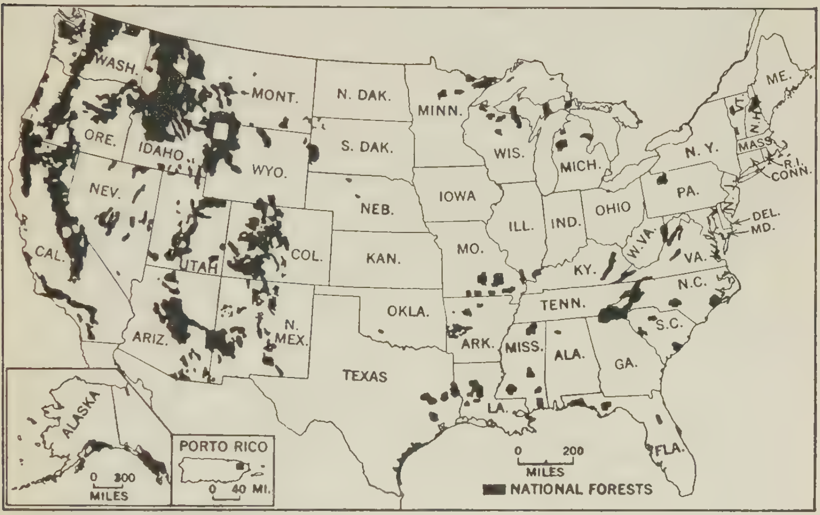

FIG. 128.

This vast area of federal forests is divided into separate administrative units of about 150 National Forests, each of which is managed by a forest supervisor and assistants. The net area of the National Forests is roughly equivalent to all of New England, New York, Pennsylvania, and Ohio, or five times the size of the state of Pennsylvania.

Principal Activities. The Forest Service has recently been reorganized under a chief forester, an associate chief, and two assistant chiefs. Under them the work has the following divisions:

FIG. 129. A great popular demand has resulted in setting aside large wilderness areas of virgin forests where primitive conditions and natural beauty will be maintained and preserved for future generations. The commercialization of some of our beauty spots should be prevented. Definite forward steps are being taken by the National Park Service and the National Forest Service to attain these desirable objectives. Photograph of Moose Lake, Deerlodge National Forest, Montana.

1. The National Forest Division, which handles timber production and sales, the development of range facilities, fire

prevention control and suppression and wildlife management, recreational uses, and engineering on the National Forests.

2. Research Division handles the investigative work in forest economics, forest influences, silvics, forest products, and range research.

3. Operations and Information Division handles personnel problems, including the recruitment of new men, changes in administrative duties, and employment and dismissal of permanent and temporary employees. It also handles all the informational and educational work and the publications issued by the Service.

4. State and Private Cooperation handles various activities, chiefly fire protection and planting in connection with state forestry organizations, and promotes and stimulates the practice of forestry by private and individual organizations, principally lumbermen, pulp and paper companies, farmers, etc.

5. Acquisition Division handles land purchases and land planning. Since 1932, over $44,000,000 have been expended to purchase forest lands.

6. Emergency Conservation Work Division handles the camps of the CCC. Most of these camps are located on National Forests where the big share of the forestry work is being done.

7. Fiscal Control handles the spending of available appropriations and the allocating of funds to the various regional and other headquarters.

Opportunities for Employment. There are approximately 3400 men on the permanent rolls of the Forest Service, of which about 1500 are technically or professionally trained men. All permanent positions, including the technical ones, are filled through examinations and certification by the Civil Service Commission. Most employees in the technical work enter at a salary of $2000 per annum, although appointments are occasionally made in the higher grades. Employees after completion of a year's probationary or trial period are duly advanced by degrees as their qualifications and abilities permit. The minimum rates in the various grades are $2600, $3200, $3800, $4600, and $5600. The following table shows personnel and the salaries of the various men who are employed on a typical National Forest.

Personnel	Salaries
Forest supervisor	$2900-$5400
Assistant forest supervisor	2300- 3500
Logging engineer	3200- 5400
Chief lumberman	2600- 3200
Associate forester	3200- 3800
Associate range examiner	3200- 3800
Assistant forester	2600- 3200
Assistant range examiner	2600- 3200
Forest ranger	2000- 2900
Junior forester	2000- 2600
Junior range examiner	2000- 2600

Fig. 130.—Operating a tractor and rooter on a road project in northern California. Horses are used to haul big stones from the right-of-way. Road construction was one of the first and most important projects of the Civilian Conservation Corps, to make our National and State Forests more accessible so that timber and other forest products could be removed at a minimum cost and means of access provided for those seeking recreation through camping, fishing, and hunting.

Work on the National Forests. The principal work is on the National Forests. Each forest has an approximate acreage of one million acres and is in charge of a forest supervisor with technical advisers and construction and clerical assistants. The headquarters office is established in a centrally located city, where contacts may most readily be made with the users of the forest — the lumbermen, cattle and sheep owners, vacationists, special-use permittees, local ranchers, and farmers. For example, Seattle is the headquarters of the Snoqualmie National Forest, Los Angeles of the Angeles, Colorado Springs of the Pike, St. Louis of the Clark, Duluth of the Superior, Iron Mountain, Michigan, of the Ottawa and Butte, Montana, of the Deerlodge National Forest. Other headquarters may be located in some of the smaller but locally very important communities.

Fig. 131.—One of the many important activities of the Civilian Conservation Corps is construction of telephone lines. They have made many other improvements to reduce fire hazards and to improve the growing conditions of our forests. Photograph on the Monongahela National Forest, West Virginia.

Each National Forest is divided for administrative purposes into from 4 to 10 or more ranger districts, each under a District Ranger, who may have one or more assistant rangers, guards, junior foresters, or others to carry on the work assigned to them.

The number varies with each forest and with each ranger district. Some are chiefly concerned with timber sales or with tree planting, grazing, fire protection, recreational use, improvement cuttings, insect or disease control, or with bridge, trail, road, telephone line, or lookout construction. Some are busy with all of these activities. The CCC camps provided men to put our Federal Forests in excellent condition for future management and growth, and especially for the prevention and control of fires, a safeguard prerequisite to the management of all forests. Sustained yield is the paramount consideration on important timber-growing forests. The number and character of men on each National Forest are determined by the nature and intensity of the work to be done; on important timber forests, logging engineers, lumbermen, and scalers with professional forestry training may be employed to handle timber sales. On severely cut-over and burned lands, such as are found in Michigan, planting is the most important activity. On important grazing forests, range examiners may be employed to allocate grazing areas, control livestock, etc. In Florida, turpentining and the sale of other forest products may be the principal activity. Additional guards, lookout men, etc., are employed on some forests during the summer. On some forests such as are in California, the White Mountains of New Hampshire, and the Southern Appalachians, special guards and assistants are employed to handle the thousands of people who use these forests for a week-end holiday or for longer periods. The allocation of tourists to the various camping and picnic grounds constitutes a real problem in some of these forests.

Research. The Forest Service is the largest and most important agency engaged in forestry research. The principal activities are in forest utilization with the largest and most important forest products laboratory to be found in the world at Madison, Wisconsin. The Service also conducts active and effective research in the fields of forest economics, silviculture, forest taxation, range management, soil erosion, climatic influences, and many other phases of the subject. A large number of specialists are employed in the various phases of forest research and the work is divided among 12 forest experiment stations with headquarters at New Haven, Connecticut, Philadelphia, Pennsylvania, Asheville, North Carolina, New Orleans, Louisiana, Columbus, Ohio, St. Paul, Minnesota, Fort Collins, Colorado, Missoula, Montana, Tucson, Arizona,* Las Cruces, New Mexico,* Berkeley, California, Portland, Oregon, and Ogden, Utah. Technical men are secured for this work as described for the general Forest Service work.

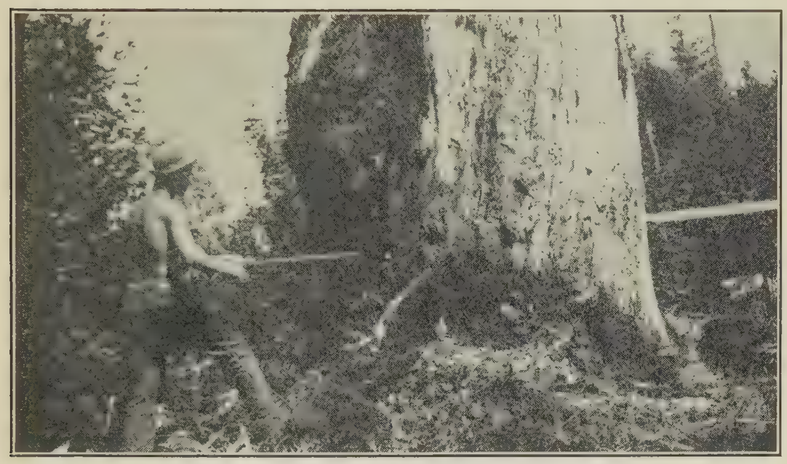

FIG. 132.—Boring a hole with power borer preparatory to falling a snag (dead standing tree) with use of powder in Columbia National Forest, Washington. These snags constitute a serious menace especially in the western forests.

Miscellaneous Activities. As indicated under " Principal Activities " above, there is considerable work done beside National Forest operations and research. For example, there are state and private cooperation, acquisition of timberland for new National Forests, and several other activities.

Emergency Conservation Work
Civilian Conservation Corps

The CCC program, as it is popularly known, was inaugurated by President Franklin D. Roosevelt on March 31, 1933, and represents the most notable contribution to the advance of forestry since the establishment and organization of the National Forest System under President Theodore Roosevelt and Chief Forester Gifford Pinchot. In many ways it is the greatest and most significant contribution to the forward progress of forestry because it has resulted in putting our " forestry house " in order. In spite of the excellent efforts toward prevention, great forest fires have heretofore swept over our mountains, epidemics of beetles have ruined thousands of acres of forests, and the blister rust and other diseases have injured or killed thousands of valuable trees. Much money has been spent and thousands of men have been employed for many years in protecting our forests against fire, insects, and disease.

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*These are Range Experiment Stations.

FIG. 133.—Roll call in a Civilian Conservation Corps Camp in the Sierra Mountains of California.

Through the widely approved CCC program, 310,000 men became available by July 1, 1933, for the work of salvaging, developing, improving, and protecting the forests and other natural resources in 48 states of the Union, as well as in Alaska, Hawaii, and Porto Rico. The enrollment has varied from

241,000 men in March, 1935, to a peak strength of 505,000 on August 31, 1935. The present authorized number is 350,000 in 2109 camps located in every state in the Union.

Federal Agencies Cooperating in the Work. Five departments participate in the CCC program. The Department of Labor selects young men from 17 to 28 years of age, their selection being based upon population quotas. Therefore the men come largely from the great urban centers. The War Department is charged with enrolling the men and providing their clothing, food, transportation, housing, and medical attention. At first the men are sent to various army posts for conditioning and then transported, usually by train, to their destination. The Department of Agriculture has technical supervision of the actual forestry work of the CCC, principally on National Forests. Many camps have also been assigned within this Department to the Soil Conservation Service, State Forests, private forests, drainage projects, Tennessee Valley Authority, U. S. Biological Survey, and others. The Department of the Interior has technical supervision over work projects on National Parks and State Parks. Veterans Administration has the selection of war veterans' applications for enrollment beyond the above mentioned age limit.

Special Features of the Program. It was primarily a combined social relief and conservation program for unmarried men with dependents at home. Each is paid $30 per month, of which $25 goes directly to the dependents. In addition to this remuneration, the men are fed, housed, transported, clothed, and furnished with necessary tools and equipment. As most of the boys are unskilled and inexperienced in the work of the woods, it became a great training ground for them. The work was done largely with the axe, shovel, pick, crosscut saw, peavy, canthook, bulldozer, and other woods tools. About 200 men were assigned to each camp, which was in charge of a camp commander, usually an army captain, and a few assistants. The work outside the camp in the woods was in charge of a camp superintendent and from 5 to 10 or more forestry foremen. The men worked a minimum of 8 hours per day, or 40 hours per week, Saturday being given over to camp clean-up and miscellaneous duties. No army discipline was permitted, not even drilling with rifles and the usual military salute. The camps were designed as civilian rather than military. The men were housed in barrack-type buildings in winter and tent camps in summer, depending on the weather, altitude, and climatic conditions. The principal buildings in each camp were the mess and cook hall, sleeping barracks, recreation hall, a tool and equipment house, a garage, and individual sleeping quarters and offices for the army officers and forestry supervisors and other assistants. Only 35 to 40 cents per man per day was allowed for food supplies, not including cost of transportation. The men usually gained from 10 to 25 pounds each during the first six months period of enrollment. Medical attention was available in all camps nearly every day, but, because of the vigorous, healthy outdoor work done, little medical attention

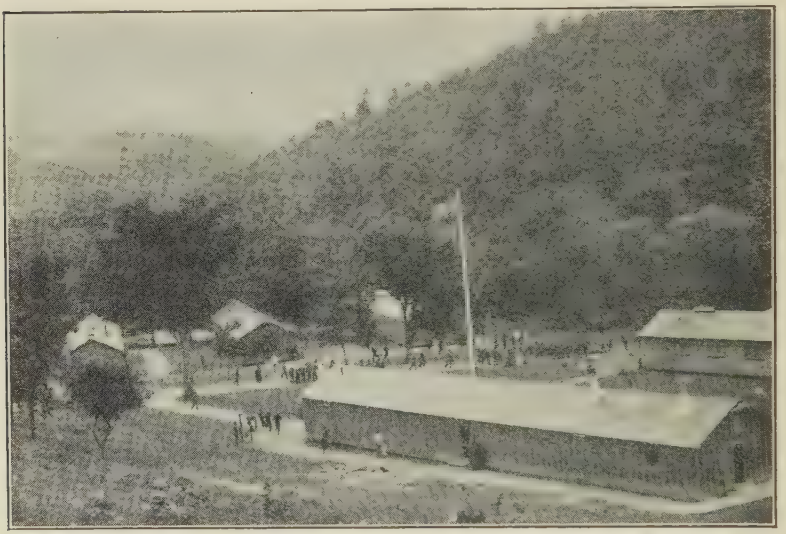

FIG. 134.—A typical, neatly arranged and orderly barrack-type of Civilian Conservation Corps camp known as Camp Alvon in West Virginia.

was required. Accidents were remarkably few. The number of camps within each state depended upon the priority of important conservation projects, area of forests requiring work, such as planting, fire protection, road building, etc., and population. Recently an average of about 12,000 boys per month have left the camps to accept employment, so there is a constant succession of recruitment to fill the camps.

FIG. 135.—Civilian Conservation Corps boys using a Hazard seeder to plant locust seeds at the Clinton nursery near Knoxville, Tennessee, which has a capacity of about 25 million trees. Black locust is widely used for erosion control. (Photo by Tennessee Valley Authority.)

Local business was materially aided by this program. The cost of constructing each camp was about $22,000, so that about 21 million dollars was placed in circulation for camp construction alone. In addition, large numbers of automobiles, woods' tools, and equipment were purchased for proper efficiency and maintenance of the camps.

Religious services are available in every camp on Sundays, the character of the service depending upon the prevailing representation of the various faiths.

During the past year 1319 educational advisers were appointed to the camps, all of them being college graduates. The educational program had as its principal objective the elimination of illiteracy, general vocational training, cultural and general education, health and safety education, character and citizenship training, and assisting the men to find employment.

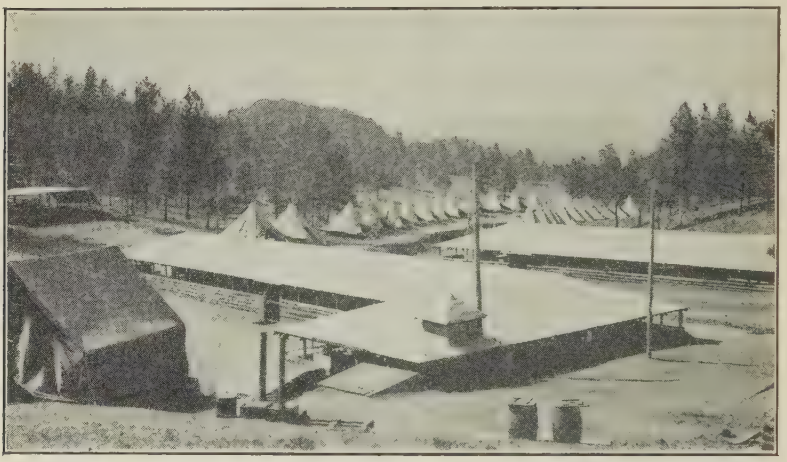

FIG. 136.—General view of a Civilian Conservation Corps near Lake George, Colorado. From lower left to upper right, are supply tent, kitchen, and mess hall combined, a recreation hall and tents used for sleeping quarters. Camp locations are carefully selected for an adequate and pure water supply, good drainage facilities, and proximity to the forestry work, and to some road which can be used to bring in men and to haul supplies.

General Classification of Work. This program has advanced the cause of conservation at least 30 to 50 years beyond the normally expected progress. The work and accomplishments may be summarized as follows:

(1) Structural improvements, such as bridges, fire lookout towers, telephone lines, and service buildings, such as rangers' stations, tool sheds, and caches, and many similar structures. More than 2,700 fire and observation towers and 50,000 miles of telephone lines were erected.

(2) Such transportation improvements as truck trails and minor roads and highways, airplane landing fields, etc. Probably the largest number of men are employed in building forest

roads and trails to check forest fires, to make our National Forests and Parks more accessible to the public, and to facilitate the removal of saw logs and other products of the forest at a minimum cost. About 76,000 miles of roads and trails have been built.

(3) Erosion control, including thousands of check dams, terracing, terrace outletting, and vegetative covers, and including the planting of trees and soil-holding plants, grasses, etc. More than 2,500,000 check dams were built to prevent erosion.

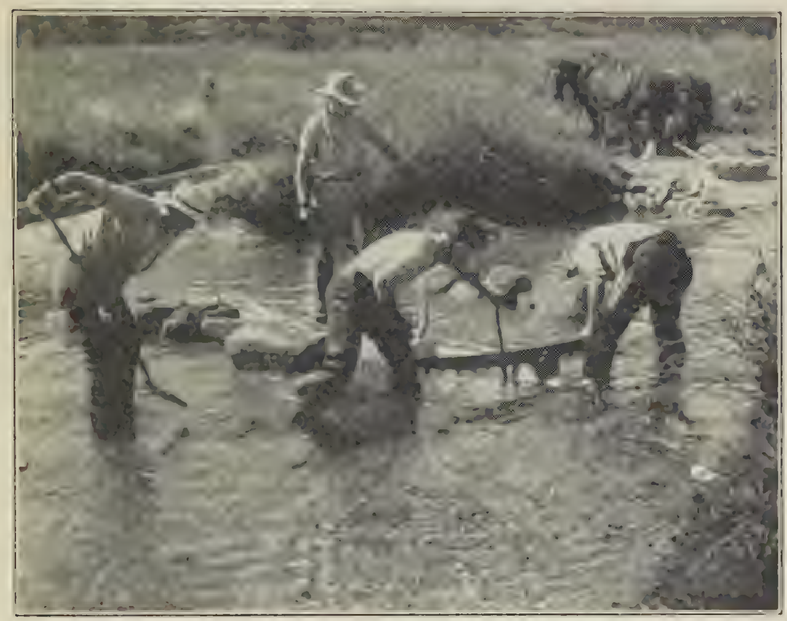

Fig. 157.—Constructing anchorage for a dam built as a part of stream improvement work on Rock Creek, Deerlodge, Montana.

(4) Flood control, irrigation and drainage work, including dams, channel work, etc., ditching, rip rap, and similar work.

(5) Forest culture, including planting of millions of trees, thinning, and other phases of cultural stand improvement, as the development of great nurseries, collection of tree seeds for

planting, etc. Over one billion trees have been planted to reforest waste areas and to stop erosion.

(6) Forest protection, including fire fighting, fire prevention, and suppression of fires, together with insect and disease control and suppression. Millions of dollars worth of timberlands have been saved by over 3,000,000 man-days spent in fire fighting.

(7) Landscape and recreational development, including public camping and picnic grounds facilities, lake and pond clearance, roadside landscaping, trails, beauty spots, etc. More than 600,000 acres of new state park lands were opened up and improved.

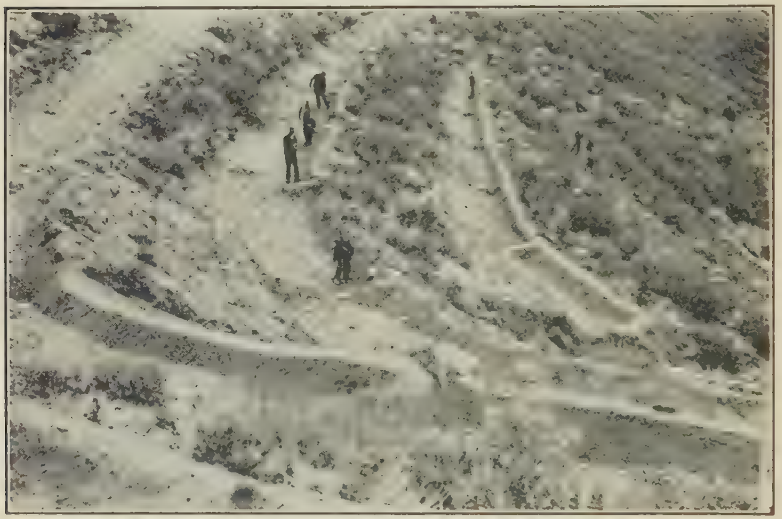

FIG. 138.—Finishing terraces to prevent erosion in Davis County, Utah. There are over 100 different kinds of work which the men of the Civilian Conservation Corps are doing.

(8) Range development, including development of livestock driveways and better water holes, elimination of predatory animals, such as mountain lions, bears, coyotes, and the poisoning of gophers and ground squirrels.

(9) Wildlife development, including stream improvement, stocking of streams with fish, emergency wildlife feeding, plant food, and cover planting.

(10) Miscellaneous, including such emergency work as may arise from time to time, as special surveys, and mosquito control.

Opportunities for Employment. In 1937 in the CCC camps, there are 333,000 enrolled men to be supervised in their forestry work. The Department of Agriculture alone has 12,630 field supervisors, technical foresters, and other employees, and the Department of the Interior has 5306 technical employees devoting their time to forestry and associated operations in the CCC program. All technical employees in work supervision, including a new designation, Junior Assistant to Technician, are appointed by the Departments of Agriculture and the Interior. The employees are selected from the eligibility lists of the Civil Service Commission. Recently about 2000 of these junior assistants were available for appointment at a salary of $85 per month. The scale of pay for the supervisory force in the Department of Agriculture is as follows: Supervisors or Chief Foremen, $2600 to $3200, Senior Foremen, $2000 to $2600, Foremen, $1860 to $2300, Junior Foremen, $1680 to $2040, Squad Foremen, $1200 to $1500, Sub-foremen, $960 to $1320.

While the CCC program has been effective and successful in rebuilding, protecting, and improving our forests, it has been equally proficient in building young men for the responsibilities of life. Their health and outlook on life have been vastly improved and a sense of self reliance and self respect has replaced discouragement and disillusionment occasioned by unemployment during depression years. Originally a social relief and conservation measure, the CCC program has proved so successful that it will be continued as long as serious unemployment exists and funds are available.*

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*In 1937, Congress passed a bill to extend the CCC program.

National Park Service

This service was created by Congress in 1916 to administer and protect the National Parks in the Department of the Interior. For many years prior to this date a number of areas, marked by outstanding and notable scenic, picturesque, geologic, botanic, and scientific qualities, were set aside chiefly from the Public Domain to be held in perpetuity for the pleasure, benefit, and enjoyment of the people without commercial exploitation, use, or development. The most notable, best known, and oldest of these parks is Yellowstone Park, created in 1872, located in northern Wyoming. However, as early as 1832 the Hot Springs Reservation in Arkansas was set aside because of the healing qualities of its waters; in 1921 it was established as the Hot Springs National Park.

In addition to the 24 National Parks there are 68 other reservations known as National Monuments which have been reserved because of particular historic, prehistoric, or scientific interest, and 36 additional areas important in our military history, such as the Gettysburg Battleground.

The preservation of the superlative values found in most of the National Parks is a matter of great national importance and requires the abilities of well-trained men. Several scenic locations of unusual beauty are perhaps not rivaled in any other part of the world. Included in these parks are the Grand Canyon in Arizona, the Yosemite in California, the Sequoia, which has 60% of all the remaining sequoias, the Great Smoky Mountain in North Carolina and Tennessee, with over 150 varieties of hardwoods and over 1500 varieties of wild flowers, Mount Rainier Park in Washington, which contains 28 separate glaciers, and the largest single-peak glacier system in the country, the Mesa Verde Park in Colorado, with the best preserved cliff dwellings in existence, and the Rocky Mountain National Park, including the heart of the great Rocky Mountain chain with a magnificent series of peaks from 11,000′ to over 15,000′ elevation.

The objectives of the National Parks vary fundamentally from those of the National Forests. The latter were originally created principally for timber production but also to conserve waterflow, to develop and use the grazing facilities for many millions of livestock, and to develop power projects. The parks, however, are preserved in their primitive and natural condition. A few roads are built, as well as hotels, camping grounds, and other facilities for tourists; but there is no commercial development. Many attempts have been made to use some of these areas for irrigation, power, or reclamation projects, or for other commercial development, but the general sentiment of the people has consistently resisted all moves in this direction. The latest attempt was to provide a tunnel in the Rocky Mountain National Park. On the other hand, many purchases of private holdings within or adjacent to these parks

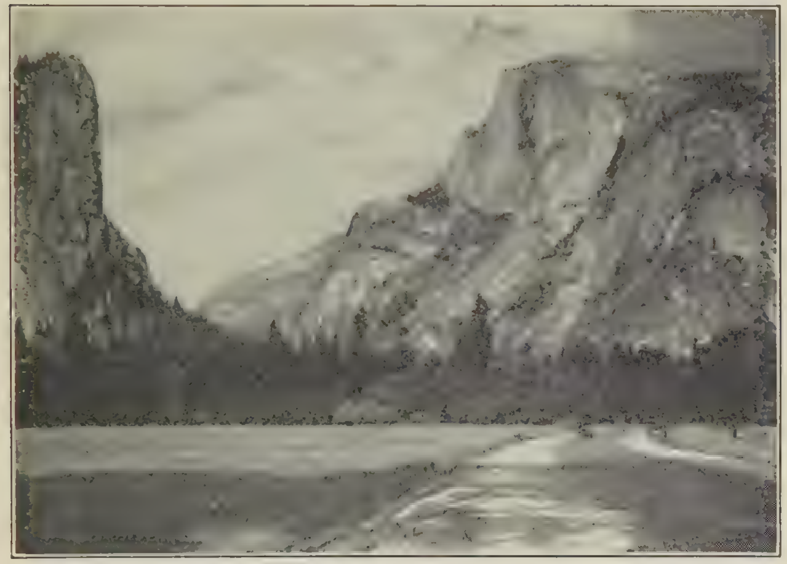

Fig. 139.—The precipitous cliffs of Half Dome in Yosemite National Park, California. Fortunately the outstanding scenic, geographic, and historic points of interest are being preserved for future generations in our National Parks where millions annually enjoy some of the finest facilities for recreation.

have been acquired to prevent lumbering or the development of projects inimical to the best interests of the local park administration.

These parks vary in size from the Yellowstone, which has 2,200,000 acres, to the much smaller-sized parks, as Wind Cave in South Dakota, with an area of 11,000 acres, Fort McHenry in Maryland, 47 acres, Abraham Lincoln Park in Kentucky, 110 acres, and Carlsbad Caverns in New Mexico, 9959 acres.

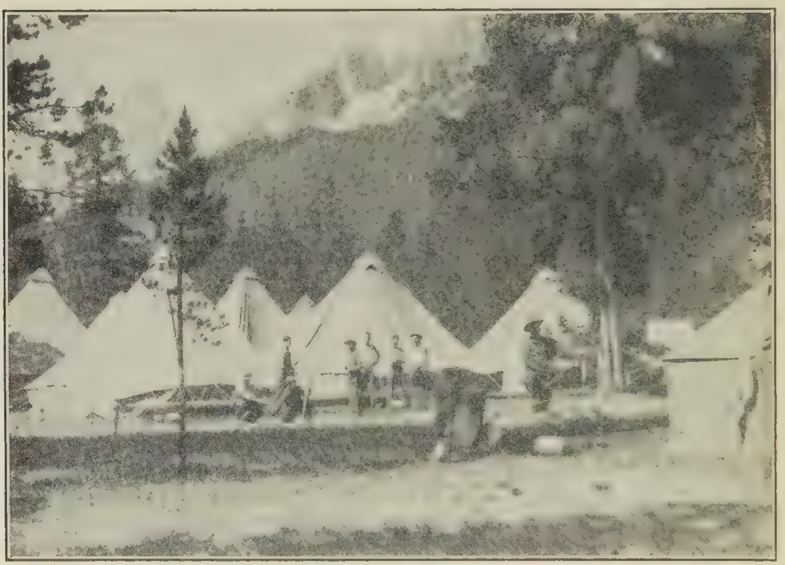

Fig. 140.—A Civilian Conservation Corps in the Grand Teton National Park in western Wyoming. Tent camps are sometimes used in the summer or in the South and the wooden barrack type of camp in the winter in the northern regions and at higher elevations.

Enthusiastic chambers of commerce and other local groups are constantly seeking the creation of additional National Parks, but the policy of creating only those outstanding areas that have a broadly national interest is being pursued. Recent additions to the National Parks system are the Everglades in Florida, Isle Royale on Lake Superior, the Shenandoah in Virginia, and the Mammoth Caves in Kentucky. Some of the finest and largest herds of elk, bison, antelope, mountain sheep, and goats are to be found within our National Parks.

There are approximately 1300 employees in the National Park Service. Of these, more than 50 are directly engaged in forestry phases of the work, and in related lines many more who have been trained in professional forestry schools. The entering salaries for those directly engaged in forestry work in this service are:

Junior forester	$2000
Assistant forester	2600
Associate forester	3200
Forester	3800
Senior forester	4600

Advancement from the lower to the higher grades depends on the efficiency and increased usefulness of the employee and the occurrence of vacancies in the higher positions. All positions are under Civil Service Commissions and are obtained by examinations within the rules of this commission.

The Indian Service

Under the Commissioner of Indian Affairs in the U. S. Department of the Interior, 71 million acres of land are held in trust for the American Indian. Of this area, about 9 million acres of timberland are under the jurisdiction of and managed by the Forestry and Grazing Division of the Indian Service. These acres are located on 50 Indian Reservations in 13 states. There are 40 million acres of grazing land which are of major importance to the local regions.

The forestry lands are chiefly located in Washington, Oregon, Arizona, and Montana, in order of importance. They are also found in most of the Rocky Mountain, Pacific Coast, and western prairie states. These stands of timber are typical of the regions in which they are located. They contain approximately 30 billion b. f. of merchantable timber with a value of approximately 100 million dollars. Timber is cut under federal regulations, as on the National Forests. In the peak year of production, over 600 million b. f. were cut, valued at more than 2½ million dollars.

The "checkerboard" ownership of timberlands on Indian Reservations constitutes a most difficult problem of forest management. Forest policies consistent with the best silviculture to fit local conditions are followed and timber is cut under contract and careful supervision, as on the National Forests.

As these lands are held in trust for the Indians by the U. S. Government, recent policies have been directed toward giving the local tribal Indians as much responsibility in the handling of their affairs as is consistent with good business management. Many small sawmills have been installed and operated to produce lumber and other materials for local building requirements of the Indians, as well as to supply lumber for the general commercial markets. These small sawmills usually have a capacity of from 2000 to 20,000 b. f., each, per day. On the Red Lake Reservation in Minnesota and the Menominee Reservation in Wisconsin, there are two large lumber operations, the former having an output of about 5 million b. f. per year and the latter much more. The former was begun in 1925, the latter in 1908; and they have been operated continuously, giving employment to large numbers of Indians and providing a steady income for them. The best principles of forest management, including selective logging, have been attempted on these areas. Extensive cutting operations have been practiced on the Klamath Reservation in Oregon. The sale of stumpage to independent operators and the small sawmills operated by the Indian Service provide employment for large numbers of local Indians.

There are 207 employees in the forestry and grazing division, 122 of whom have had technical training or are engaged in technical work. These positions are filled through civil service examination, usually as junior forester, junior range examiner, etc., or through transfer from other agencies. Salaries usually begin at $2000; later positions command salaries of $2600 to $3800, depending upon the responsibilities and duties of the various positions. A few regional supervisors enjoy salaries ranging up to $4600. Positions below those of forest ranger are usually filled by qualified Indians. The new policy is to recruit the summer forest and range protective organizations from Indians on the local reservations.

Soil Conservation Service

This is one of the most important conservation measures of the Franklin D. Roosevelt régime. It was created by order of Secretary H. L. Ickes, Public Works Administrator, in August, 1933, with an initial allocation of $5,000,000. Later several allotments were made and a large organization built up to handle the pressing problems involving soil conservation. Originally in the Department of the Interior, it was transferred in April, 1935, to the Department of Agriculture.

This is the first attempt to organize on a national scale problems of soil erosion, flood control, and related problems. The plan involves the integration and proper relating of complex engineering, forestry, and cropping measures, as may be determined by the character of the land and its present condition. Nearly every section of the country that has been deforested, chiefly for agricultural purposes, has suffered from soil or sheet erosion, as well as from severe gullying and washing as a result of repeated and heavy precipitation.

Although the fundamental objectives of the Soil Conservation Service are to protect, preserve, and maintain the great agricultural wealth of the nation from impoverishment and depletion through loss of fertile top soils and resultant gullying and silting of the valleys, it is intimately related to the problems of afforestation and reforestation. It is becoming widely recognized that forests and forest soils have enormous value in the retention of precipitation in the form of rain and snow. Many forests have been cut on slopes too steep and thin-soiled for successful agricultural development. In many sections of the South, Middle West, and East, notably in the Tennessee Valley, enormous damage has been done by silting of the valley floors and stream bottoms, thus ruining many thousand acres of rich farmlands, interfering with the navigability of streams, filling up reservoirs and dams with silt and detritus, and doing many other forms of damage. It is estimated that enough top soil is annually washed down the Mississippi River to build 1250 farms of 160 acres each, with a soil depth of 12″. More than 400 million tons of suspended solid matter of our best agricultural lands pass annually out of the mouth of the Mississippi River or cover the adjoining land during flood periods. It is estimated that about 100 million acres of the most fertile lands of the nation have been rendered worthless, or nearly so, by the stripping of their top soil by sheet erosion and gullying. About 75% of all farmlands of the country are so located on steep topography that they are subject to erosion and soil washing. Thus the subjects of forest, farm, and pastureland are closely coordinated.

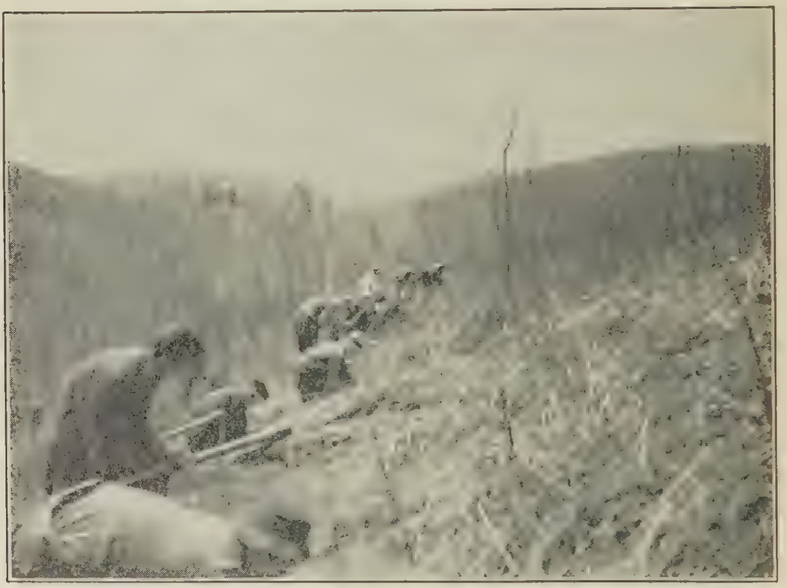

FIG. 141.—Planting crew of Soil Conservation Service putting in little seedlings with a mattock on a typical cut-over and burned-over area near Hinkle Run, West Virginia.

Although a comparatively new subject, government specialists have been working on the problem of soil conservation for a good many years. The problems have reached such a critical stage that for the first time they are receiving nation-wide attention. The method of procedure in handling them depends upon the requirements of each type of land used and coverage, special attention being given to soil crops, slopes, precipitation, etc., and to past and present cover. The training and experience of the forester, agronomist, soil specialist, and agricultural engineers are required in working out conjointly the proper solutions of each particular local condition. Owners of lands are requested to cooperate and to make definite contributions. Much land may be purchased and developed on the basis of regional or even national benefit. Three important control measures are applied, that is (1) the planting of trees, shrubs and grasses to prevent further erosion, (2) mechanical methods, such as the construction of dams of timber, rock, concrete, or other forms of material, and (3) terracing.

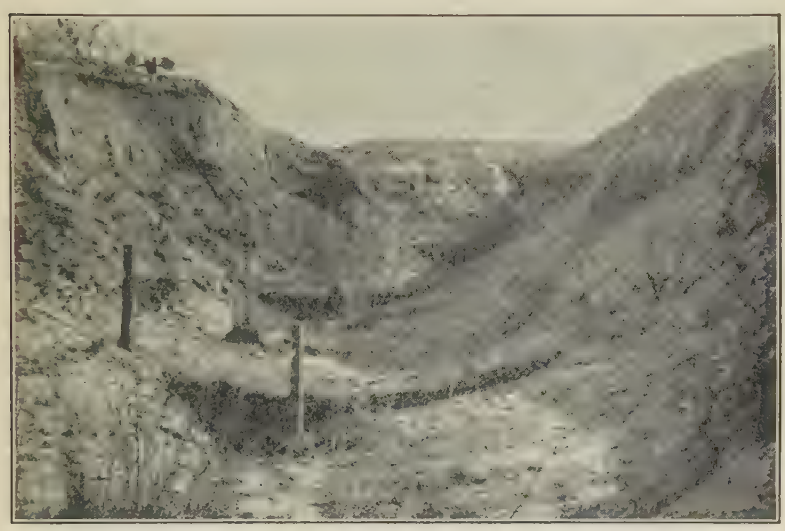

FIG. 142.—Wire dams checking gully erosion in Marshall County, Mississippi.

Some of the most important projects are being developed near La Crosse, Wisconsin, Spartanburg, South Carolina, Bethene, Missouri, Pullman, Washington, Spencer, West Virginia, High Point, North Carolina, Zanesville, Ohio, and several other points throughout the South, Middle West, and Far West. The largest single projects are the one on the Navajo Indian Reservation, with headquarters at Albuquerque, New Mexico, and the Gila River project at Safford, Arizona.

Many experiments are being conducted to develop the best and quickest-growing varieties of trees, shrubs, and grasses to serve local purposes. Black locust, honey locust, shortleaf pine, and loblolly pine have been widely used in the South and Southeast. Black locust and several of the quick-growing pines are used in the Central States and portions of the Lake States. It has been demonstrated that the construction of dams and terraces alone is not sufficient. A combination of tree planting, dam construction, terracing, and development of new and better kinds of grasses has proved to be most beneficial in many areas. It will be many decades, perhaps centuries, before the complete results of present efforts will be disclosed. Soil conservation is fundamentally a long-time proposition, but erosion conditions have been permitted to continue so long that it is important that very definite measures be taken to prevent the further erosion which is commonly found in nearly all parts of the country.

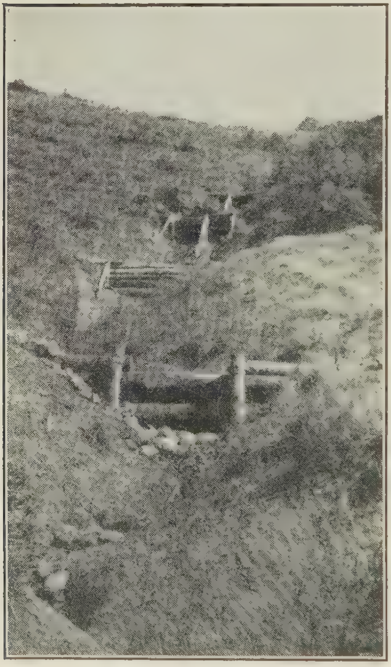

Fig. 143.—Brush and log dams to prevent erosion in southern Colorado. Areas adjoining the stream bed are then planted with trees.

Men trained in forest schools are employed in nursery, reforestation, and other phases of timber management, as well as surveying, mapping, and related work. Appointment is made from eligible lists secured through civil service examination as described for the U. S. Forest Service, National Park Service, and other governmental agencies.

Tennessee Valley Authority

One of the important programs initiated during Franklin D. Roosevelt's first administration and authorized by Congress on May 18, 1933, is the Tennessee Valley Authority with headquarters at Knoxville. The Authority is managed by a board of three directors appointed by the President and approved by the Senate.

The Authority was created because of these conditions, which made the planned development of the Tennessee Valley desirable:

(1) The idleness of the Muscle Shoals power and nitrate plants.

(2) The need for the development of a 9-foot channel for inland waterways transportation from Paducah, Kentucky, to Knoxville, Tennessee.

(3) The development and sale of the power resulting from the construction of dams for the above purpose.

(4) The need to cope with and alleviate a valley-wide land use problem which has resulted in serious erosion and rapid runoff, contributing to and accentuating the damage from floods.

(5) The incomplete development of the natural resources of the Valley as compared to its ultimate possibilities, leading to the selection of this area for a new social and economic experiment on a broad scale.

The Tennessee Valley embraces the drainage basin of the Tennessee River, draining portions of seven states — Tennessee, Virginia, North Carolina, Georgia, Alabama, Mississippi, and Kentucky.

This area of approximately 26 million acres (the size of Ohio, Virginia or Tennessee) is 52 % forested, the remainder being in cleared land. The Valley supports a population of about 2½ million people, 25% of whom live in the cities, 50% on farms, and the remainder in small rural communities.

The Tennessee Valley Authority Act provides that the Authority shall serve as a coordinating and unifying agency to develop the possibilities of unified control and to assist in coordinating the efforts of the many agencies involved in the development of land use, such as the various departments of the national government, the state and local governments, as well as private organizations. Without such an Authority there would be no all-inclusive, coordinating medium. The principal problems attacked are those of watershed protection, flood control, the development of navigation on inland waterways, the prevention of stream pollution and silting, improvement of domestic and industrial water supplies, the improvement of agriculture through experiments in the use of fertilizers, and the

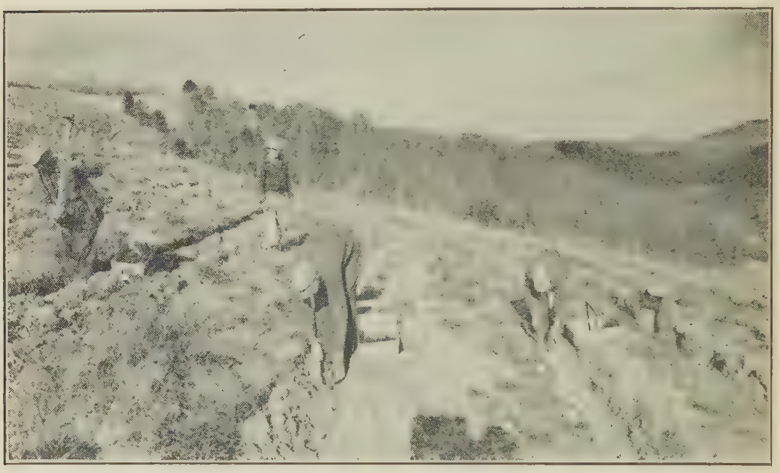

Fig. 144.—Men of the Civilian Conservation Corps planting pine on an eroded field in the Tennessee Valley. Ditches are made along the contours to prevent sheet or surface erosion and the trees planted in these ditches or furrows. Trees gain the benefit of additional moisture and better protection and will grow more rapidly as a result.

development of power as an accessory to the above-mentioned plans. These problems are very closely interrelated, and, in some cases, become interstate problems. For example, the flood control problem is not only one of constructing levees and dams, but there must be combinations of levee and dam construction, channel improvement, water storage, erosion control, reforestation, and development of agricultural and forestry practices that lead to a reduction in runoff and soil erosion. If half the drainage area of the Valley could absorb 4″ more rainfall than at present, there would be an additional storage value as great as that of the huge Norris Dam.

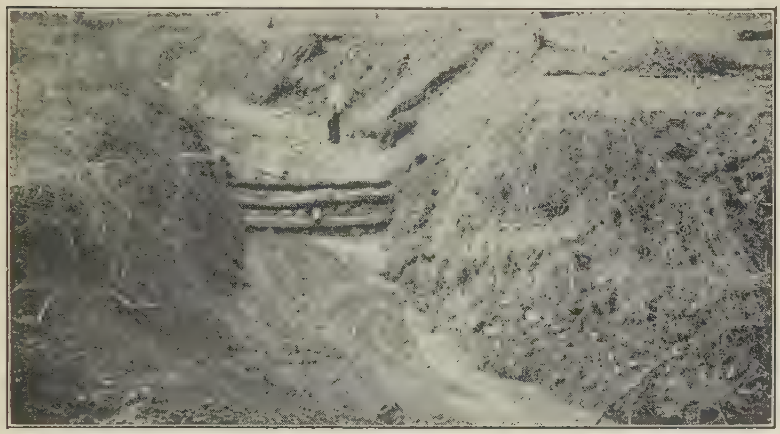

Fig. 145.—Crib dam built of dead chestnut and fieldstone. The gully banks have been plowed in and seeded to grass and then covered with brush matting. The silt basin behind the crib dam is already silted full and will be planted with grasses and trees. (Photograph by Tennessee Valley Authority.)

Although over one-half the Valley is timbered, a relatively small area of the timber is of commercial size and value, owing to the fact that the forests have been consistently culled over for their more valuable species and sizes. In some of the valleys the forests occupy as much as from 70% to 80%, or more, of the total area. The forestry problem is primarily one of maintaining and improving the existing timber lands, of restoring marginal and submarginal lands now seriously eroding or likely to become a serious erosion hazard, and generally developing the whole forest area so that it will provide the maximum value for water-storage and watershed protection purposes, as well as provide wildlife, raw materials, regular employment, and recreational opportunities. The widespread custom of burning woodlands each year has seriously destroyed the leaf cover and humus, thereby reducing the permeability of the soil, and, consequently, seriously affecting its water-holding capacity.

These problems are being solved by (1) providing cooperation with state and federal agencies for adequate forest fire prevention, presuppression, and suppression programs; (2) by conducting forest economic surveys and studies which will serve to bring out the relation of forests to the required economy and the measures necessary to the most constructive utilization of forest lands; (3) by developing better types and strains of forest trees, so that the productivity of the forest may be improved (this includes tree breeding as well as the production of various improved kinds of forest tree fruits); and (4) by assisting in the encouragement of stabilized ownership of forest lands

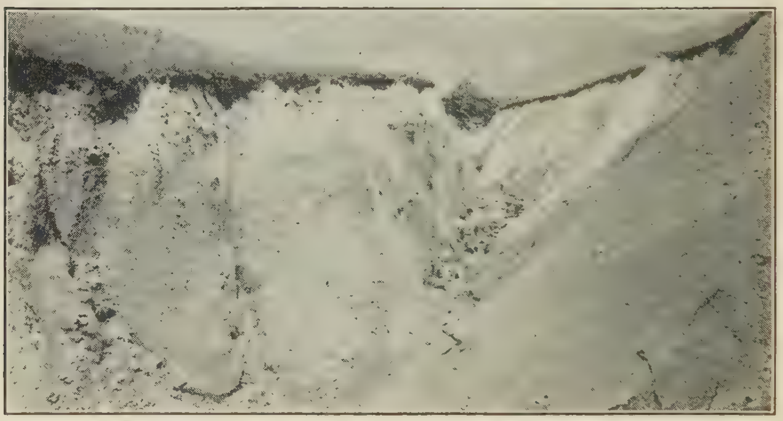

Fig. 146.—Advanced phase of erosion. Gullies of this type are treated with check dams and the banks are dynamited and plowed in to a 1 to 1 slope and then planted to soil-holding grasses and trees to prevent further damage. (Photograph by Tennessee Valley Authority.)

through fostering a program of public acquisition of the most critical forest and eroding areas for National Forests, State Forests, municipal forests, or institutional forests, which would insure their permanent protection and management.

Biological readjustment work is also being carried on to restore, develop, and manage the fish and wildlife resources adversely affected by the dam construction program, and to aid in malarial control operations through biological means.

A belt of land is being acquired around each of the reservoirs; and that around the Norris Reservoir is already being managed according to the principles of multiple-land use. The Norris Lake Forest will serve as a demonstration of the best forestry methods tied in with permanent forest-worker settlement. It is expected to be of considerable educational value.

A number of Tennessee Valley Forestry CCC camps, from 19 to 38, have been in operation. The men are used on soil-erosion control projects, in forest nurseries, for tree planting, seed collection, forest-fire prevention and suppression, stand-improvement work, and for the construction of other forest improvements. Four of these camps are assigned to the Norris Lake Forest, and four to the Wheeler Reservoir lands.

Special studies are made of the possibilities of the introduction or development of forest tree crops, including Chinese and Japanese chestnuts and persimmons, black walnuts, hickories, honey locusts, mulberries, and other crops which would not only provide a better quality of timber but which would also provide food for wildlife.

Three nurseries have been established — two for the production of trees and one for experimentation and testing of the above-mentioned special forest tree species and strains. The species grown in the first two nurseries are mostly black locust, shortleaf pine, loblolly pine, Virginia pine, cypress, tulip poplar, and other species of trees of local importance which are properly acclimated and will best grow under local climatic and soil conditions.

In 1933, the Wheeler and Norris dams were started, both of which are now completed. In 1935, the Pickwick Dam was started, and in 1936 the Guntersville, Chickamauga, Hiwassee, and Fowler Bend dams.

One of the primary objectives of the Forestry Division of the Tennessee Valley Authority is to prevent undue silting of these reservoirs by providing an adequate and continuous forest cover over the watersheds behind these dams. The area of seriously eroding land has been estimated at 3,000,000 acres, of which around 40% is in the upper valley above Chattanooga, Tennessee, and 60% below this point. Up to January 1, 1937, 23 million trees were planted by the CCC workers for the purpose of controlling such erosion. The headwaters of a large part of the upper watershed are found within the National Forests of western North Carolina, western Virginia, eastern Tennessee, and in the Great Smoky Mountains National Park. Additional areas are being acquired for National Forest purposes and should aid materially in facilitating accomplishment of the objectives of the Authority. The possibility of developing municipal and town forests throughout the Valley was also given attention by the Forestry Division of the Tennessee Valley Authority during the past year.

This work requires the services of many specialists trained in forestry, engineering, agriculture, soil erosion, and related matters. There are 70 men trained in forestry in the Forestry Division and a total of 113 trained men in the Division. The entering salary is $2000 for junior foresters obtained from the Civil Service lists. There are 6 provisional grades receiving salaries of from $2000 to $5600, with maximum rates of pay for the different grades from $2600 to $6400. Advances in salary are made after a year of satisfactory probationary service; but top salaries in each grade are paid only for specially meritorious services.

Bureau of Biological Survey

This was initiated as a bureau of the Department of Agriculture in 1905. Its purposes and function have been the development and protection of wildlife of the nation, particularly with reference to economic ornithology. Within recent years it has devoted considerable attention to the propagation and protection of water fowl, and in cooperation with various phases of the Rooseveltian conservation measures since 1933, it has been active in the expansion, development, and care of wildfowl breeding grounds and refuges. It has also protected wildlife against noxious and predatory animals, particularly the coyote, ground squirrel, gopher, cougar or mountain lion, and other predatory animals in the National Forests and National Parks.

The bureau conducts active investigations in various phases of the lives of furbearing animals, game birds, and many others.

Although a fundamental knowledge of zoology is important for participation in this branch of government service, many men trained in forest schools have secured employment in this field. There are 1121 employees under appointment. Of these 49 are engaged in planning and promoting the development of refuges for wildlife and in enforcing and administering forestry regulations in connection with proper cover, tree-food crops, nesting ground, etc.

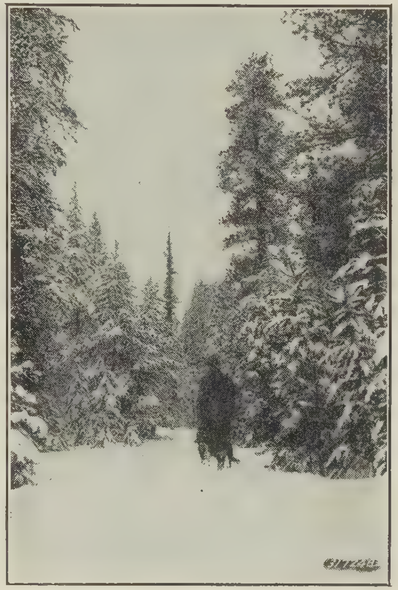

FIG. 147.—Forest ranger patrolling the forest and engaged on a game survey in one of the National Forests. The protection and preservation of wildlife through selective game management is recognized as an important part of forestry.

All employees are under Civil Service. The entering salary ranges from $1620 to $1980 for Junior Refuge Manager, $2000 to $2600 for Junior Biologist, $3800 to $4600 for Biologist in Wildlife Research and Refuge Superintendent. Examinations for these offices are held under the auspices of the Bureau. In addition, Junior Foresters, Surveyors, Engineers, and others are obtained through examinations held by other branches of government service.

Division of Grazing Control

Sentiment regarding the proper disposition and management of many millions of acres of unreserved and unappropriated lands known as the Public Domain was finally crystallized by the passage by Congress of the Taylor Grazing Act in 1934. This act established the Division of Grazing Control in the Department of the Interior to organize and administer grazing districts on the Public Domain. This is one of the important conservation measures of the Rooseveltian régime and is a notable forward step in the development of western-land usage. Although primarily designed to organize and manage the grazing resources of the Public Domain, the division is closely related to the measures providing for the conservation and reclamation of forests and the conservation of mineral resources. The vast Public Domain of 165 million acres lies chiefly in the 10 far western states and occupies an area over five times the size of Pennsylvania, or equivalent to the State of Texas. It embraces principally the vast intermountain drainage basin lying between the Rocky Mountains on the East and Sierra Nevada, and Cascade ranges on the West, together with much of the northern plains areas of Montana and Wyoming. Within this same region are important locations of our National Forest, on many of which grazing is one of the most important resources. Therefore, the allotments of grazing permits and the general management, and control of livestock must be closely integrated with National Forest grazing policies. It lies largely within the 15″-annual-rainfall regions. It is also broken up by many grazing and dry farming homesteads or by state-owned school sections 6 and 36, which were allocated to these states by the Federal Government. The transcontinental railway systems also own most of the alternate sections on either sides of their rights-of-way.

Considerable timber is found on portions of the area to be administered by this division. This is estimated to be 22 million acres of partially or completely timbered lands that have heretofore been unreserved within the Public Domain. The act provides for the protection, administration, regulation, and improvement of grazing districts and for the right to enter into cooperative agreements to insure their proper use, maintenance, and upbuilding. Unrestricted grazing in the past has seriously depleted the productive capacity of many of these lands. Both the range and forest have been repeatedly burned, over-grazed, sometimes eroded, and otherwise abused. This act provides for conservation and use as opposed to depletion and wastage.

Fig. 148.—A herd of Hereford cattle grazing on the Roosevelt National Forest, Colorado. The new Division of Grazing Control coordinates its work with the grazing administration of the Forest Service.

About 50% of the receipts from grazing fees under this act is to be returned to the states in which the areas are located, 25% is to be retained in the U. S. Treasury, and the remaining 25% appropriated for range improvement, research, erosion prevention, flood control, etc. It is expected that some of these areas may be developed and used for wildlife management, particularly game refuges, breeding grounds, and for certain forms of recreational enjoyment.

As many of the forestry schools have special courses designed to train men for range management, particularly the western forest schools, this work provides a distinct opportunity for men professionally trained in this phase of conservation. It is closely integrated with forest conservation; and, therefore, men trained in range management should have a definite understanding of the relationship of these two important resources. Men selected for this work are chosen from the eligible list of the Civil Service Commission. Examinations for positions in range management have been offered for many years by this commission.

Resettlement Administration

This is one of the important emergency relief conservation measures established by order of President Franklin D. Roosevelt on April 30, 1935. While originally designed to purchase and retire from cultivation some of the larger areas of poor crop land and abandoned farms, it is closely related to the subject of forest conservation. Many of these areas in the Lake States, East, and South are being devoted to reforestation for park and others recreational purposes, such as improved hunting and fishing grounds, and for wildlife management, particularly game preserves, rearing grounds, and associated purposes. This administrative branch was established during the economic depression to relieve rural distress, and it includes the resettlement of farms and the establishment of better housing and living conditions in special areas. Many experiments have been tried, in West Virginia, New Jersey, and elsewhere. The administration has also adjusted some farm debts and aided drought-stricken families who have suffered as a result of the severe and protracted drought of 1936. During the peak of activity, this agency employed a personnel of about 20,000, reduced in 1937 to about 14,000. In January, 1937, Franklin D. Roosevelt assigned the Resettlement Administration to the Agricultural Department as a part of the consolidation of various governmental agencies. This work has required the services of many men trained in forestry, especially in the surveying, appraisal, and acquisition of abandoned or idle lands, the establishment of nurseries, the planting of trees, and providing for recreation parks and wildlife facilities.

In many sections of the country, areas have been acquired and allocated to the various state governments for administration. Many hundred thousand acres have been acquired in this way for reforestation, wildlife management, recreational purposes, and associated fields of activity. Thus this entire program is closely coordinated with the federal forest conservation policies.

The principal activities of this administration revolve around the land-use projects designed to convert areas of submarginal and poor agricultural land to better public use as forests, parks, wildlife refuges, and grazing areas. Over 9 million acres have been purchased at an average cost for the land of about $4.40. Many of these are multiple-use projects and embrace a combination of uses such as forestry, grazing, recreation, and wildlife conservation, as dictated by the nature of the land itself and the requirements of the local region. Still others are purchases exclusively for wildlife conservation, including migratory water fowl refuges planned in cooperation with the Biological Survey. These projects are found in practically every state and involve areas from a few thousand acres up to the large projects, such as the Wakulla in Florida of 262,000 acres, Sabine Lake in Louisiana of 137,000 acres, Milk River project in Montana of 9000 acres, and the northeastern Washington project of 241 acres.

Wherever the nation's resources have been badly devastated, wasted, or destroyed, focal attention has been given to them, particularly with reference to forest denudation, soil erosion by wind and water, over-grazing of the western cattle ranges, and wasteful methods of farming. Poverty is the first and most undesirable result of land misuse. Over 9000 farm families in the United States had incomes of less than $400 yearly in 1930; over 1300 families had a net cash income of $84 yearly in 1935, earned largely by work outside the farms. These are illustrations of the necessities for resettlement and for the devotion of lands to their most profitable and permanently profitable occupancy and use.

Miscellaneous

There are several other governmental agencies which employ men with professional training in forestry. Among these may be mentioned the Division of Forest Products in the Department of Commerce, dealing with the domestic, import and export distribution of lumber, and the investigation of many technical and marketing phases of forest products; the Bureau of Internal Revenue in the Treasury Department, which has to do with the valuation of timberlands for income tax purposes; the Bureau of Standards in the Department of the Interior, which has to do with improved trade practices and standardization of specifications in the lumber, paper, plywood, veneer, and many other forest products; and the Bureau of Plant Industry, which has to do with many phases of pest injuries and the preventing, by quarantine, of foreign pests from entering the country. The Tariff Commission makes studies of the cost of production and the competition of foreign commodities with those produced in this country, and one division of it deals specifically with lumber, paper and pulp, and associated forest products in relation to tariffs. The Bureau of Entomology and Plant Quarantine also employs men trained in forestry schools.

CHAPTER XVIII

STATE ORGANIZATIONS

Of the 48 states in the Union, 42 have laws and some form of organization designed to take care of the state's forest resources and to advance generally the cause of forestry. The responsible chief of the work is usually known as the state forester, forest commissioner, director of forestry, or some similar title. Thus, forestry has been accepted and adopted by most of the states, particularly in those regions where the large percentage of forest areas justifies expenditure of state funds for the protection, maintenance, and propagation of these resources, together with closely allied fishing, game, and recreational interests. The states now own and manage 17,000,000 acres.

The South has made the most striking and notable advances in recent years and each of the 11 Southern States now has an active and successful state organization.

Each state employs from a few to 70 or more trained foresters in its organizations. New York, Pennsylvania, Washington, Oregon, California, North Carolina, Tennessee, Texas, Florida Michigan, Wisconsin, Minnesota, Massachusetts, Ohio, Indiana, and Maine employ a considerable number of forestry-trained men in their organizations and pay salaries that are comparable to those paid federal foresters. In some states the forest commissioner, or state forester, is paid a salary of $5000 to $12,000.

State forestry activities vary with the local circumstances and requirements. Heavily forested states may be concerned chiefly with fire protection. Washington and Oregon have very strong organizations to assure the future of their timber assets, thus safeguarding their industry and community life. Other states, as Iowa, Kansas, and Nebraska, are concerned principally with the planting of shelterbelts and windbreaks and with the development of small areas for park purposes. Pennsylvania has one of the strongest, best organized, and most successful of the state organizations. It has an excellent system of state forests, with a well-trained administrative force. New York has the largest area of state forests and the most important reforestation program among the states; but the state has a constitutional prohibition against the cutting of its forest properties in the Adirondacks and Catskills. Florida, Louisiana, Georgia, and North Carolina have been very active in fire protection, in extension and promotion work among farmers and other woodland owners, in the application of local tax laws, and in the encouragement of private owners to practice forestry.

The principal work of the more heavily forested states may be summarized as follows:

1. The protection of state and private lands from fire, insects, and disease. Young volunteer growth and plantations must have adequate fire protection or these timber assets will be lost and vast amounts wasted. Therefore fire protection is usually the most important single activity in forestry.

2. The purchase,* protection, and management of state forest properties including forests, parks, playgrounds, etc. In portions of California, New Hampshire, Maine, New York, and North Carolina provision for adequate recreational facilities is of very large importance.

3. Nursery and reforestation work. New York has 4 large nurseries with an annual turnout of about 50 million trees.

4. Educational and promotional work to encourage others to plant trees, eliminate fires and pest injury, and cut timber so as to insure future crops. Special foresters are often employed to give radio talks and addresses before schools, lunch-

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*The Fulmer Act, signed by President Roosevelt on August 29, 1935, authorizes $5,000,000 for the purchase by the Federal Government of lands to provide for an adequate, effective, and stable program of State Forests. The states reimburse the government through payment of 50% of the income from the properties. The National Resources Board advocates state acquisition of 77,000,000 acres of forest land by 1960 for stabilized management and use.

eon clubs, civic and women's organizations, as well as to hold exhibits at state and county fairs and stimulate Arbor Day celebrations. All these tend to promote active interest in and support of the forestry program. They also make favorable legislation simpler to attain. Some foresters are also employed in writing and distributing popular literature on forestry.

5. Cooperation with federal and private agencies in fire protection, growing trees for planting, and in farm forestry. There are 39 states now cooperating with the Federal Government in this work. Active cooperation with the CCC program, the Soil Conservation Service, Resettlement Administration, and other federal agencies, receives considerable attention in some states.

6. Development and maintenance of adequate recreational and wildlife facilities for the people of the state. These phases of the work are closely integrated with those mentioned above.

CHAPTER XIX

COUNTY, TOWN, MUNICIPAL, AND TERRITORIAL ORGANIZATIONS

Within recent years these political units have begun to engage in forestry activities largely through the acquisition of forest lands to serve both forest and park purposes. Closely allied with these purposes is recreational development. There are 390 town and municipal forests in New York, 90 in Massachusetts, 82 in New Hampshire, 45 in Michigan, 37 in North Carolina, 23 in Ohio, and many others scattered over the Eastern and Southern States. Many of these are not able as yet to employ trained foresters. Los Angeles County in California has taken a distinct leadership in forestry activities and spends over one million dollars annually for forestry purposes, chiefly in the protection of the Sierra Madre, Santa Monica, and other mountains from fires which destroy the vegetative cover and, therefore, interfere with the water-retentive features of the soil.

Onondaga County in New York has acquired about 1600 acres for forest, park, and recreational purposes and has planted over 1,500,000 trees. The county employs a forester to carry on the work.

The Territory of Hawaii has a very active and effective forestry staff. In some states, as Wisconsin and New York, special legislation has provided for state participation in county expense. Many cities employ so-called city foresters or arboriculturists to take proper care of street, park, and other public tree planting and associated tree trimming, spraying, and maintenance of shrubs and lawns, all of which may come under their jurisdiction in park departments or separate organizations. Many of our larger cities employ men trained in forest schools for these purposes.

Ventura, Santa Barbara, and other counties in California have also made substantial progress in fire protection and other phases of forestry work.

Stimulated by foresters, many luncheon clubs, civic groups, chambers of commerce, American Legion posts, Boy Scout organizations, schools, and other local groups have taken the leadership in the purchase, planting, protection, and operation of community forests on the outskirts of many cities and villages. There are over fifty million acres of idle and abandoned farms or waste lands within easy driving reach of most of our communities which could be profitably devoted to community, town, or county forests. The water departments of many cities, as New York, New Haven, Syracuse, and Seattle, have planted millions of trees about their watersheds, or taken measures to improve the condition of the forests already standing. About 3% of all foresters are employed in this general field of work.

CHAPTER XX

INDUSTRIAL, RAILROAD, ESTATE AND OTHER PRIVATE ORGANIZATIONS

According to Graves and Guise, nearly one-third of all forestry graduates of this country are employed with forest industries, even more than were employed by the U. S. Forest Service for the years 1900 to 1929, inclusive. Many of the forest industries, chiefly lumber, pulp, and paper, have been able to use men trained in forest schools to excellent advantage. According to S. W. Allen, 268 companies are making definite efforts to grow timber on about 20 million acres of land; 79 companies employ 146 foresters in timber production; and 77 companies use consulting foresters on a part-time basis to make logging plans, timber estimates, surveys, growth studies, sustained-yield or other management plans, selective logging studies, and plans for outlets for woods and sawmill waste.

There are 178 companies using careful cutting methods, such as selective logging, to assure future natural regeneration on over 10 million acres; more than 40 companies are attempting to put their holdings on a sustained-yield basis; and 253 are providing effective fire control, independent of public cooperation. Many other companies are actively cooperating with the federal, state, and private organizations to effect better protection on their forest properties. Fifteen companies maintain tree nurseries for growing planting stock and produce over thirty million trees annually for this purpose. More than 100,000 acres has been planted with trees by private companies.

Many men trained in forest schools are working directly with lumber, pulp, paper, and other industries as a regular career, just as men enter steel, automobile, cement, electrical equipment, public utility, and other great industries. When these men reach executive positions they are in a very favorable position to have such forestry measures practiced on their holdings as may be practicable under the circumstances.

Several railroads employ foresters for planting trees, managing timberland, inspecting cross ties, operating timber preservation plants, and in many other ways. The Pennsylvania, Missouri Pacific, Southern Railway, New York Central, and many other railroads have employed men trained in forest schools, either on a salary or consulting basis.

Several foresters are employed in such private organizations as estates, fishing and hunting clubs, and mining companies. Men trained in a knowledge of trees and woods are found to be useful in a great many organizations. Certainly forest schools are better equipped to prepare men for this work than engineering, liberal arts, or other types of colleges. Hundreds of college men who are annually going into forest industries have not had any forestry training. Certainly these men should have a background of information and a knowledge of the objectives of forestry.

CHAPTER XXI

ASSOCIATIONS (FORESTRY, LUMBER, PROTECTIVE, ETC.), TEACHING, AND CONSULTING FORESTRY

Many associations employ men trained in forestry to carry on promotive, educational, editorial, or other work. The American Forestry Association, the American Tree Association, and several state associations, notably those in Massachusetts and Connecticut, have successfully employed forestry trained men. Many of the lumber and fire protective associations employ foresters or have them at the heads of their organizations. Foresters are employed as the managers or within the organization of the West Coast Lumbermen's Association of Seattle, the Western Pine Association of Portland, Oregon, the Redwood Association of San Francisco, the Southern Pine Association of New Orleans, the Northern Hemlock and Hardwood Association of Oshkosh, Wisconsin, the National Lumber Manufacturers Association of Washington, D. C., the Northeastern Lumber Manufacturers Association of New York, the Western Forestry and Conservation Association of Portland, Oregon, the American Pulp and Paper Association, the Newsprint Bureau, and many of the state and regional fire-protective associations, notably in the Pacific Northwest, where this work has been most successful and effective.

Teaching has given employment to about 9% of the foresters over a 30 year period. There are a few changes from time to time in the personnel of the 25 professional forestry schools of the country, and, with added appropriations, more men are being placed on the faculties and employed on research and as general assistants.

Consulting forestry has engaged the attention of about 2% of the forestry graduates. The consulting forester has generally enjoyed wide experience and knowledge of forestry and possesses ability to organize, advise, and carry on the work of managing timber properties, fire protection, purchase and sale of timberland, and handling of delicate local, state-wide, and national taxation matters. He must be conversant with logging engineering, sawmill operations, marketing of forest products, special work in the fields of timber preservation, forest utilization and valuation for income tax purposes, and many phases of silviculture, forest economics, forest finance, and administration. The work is very exacting and requires wide experience, keen judgment, and a knowledge of the details of these subjects. On important cases very attractive remuneration is often paid for these services.

APPENDIX

SELECTED BIBLIOGRAPHY AND REFERENCES FOR MORE EXTENDED READING

These are in addition to the numerous government publications available at low cost from the U. S. Forest Service, National Park Service, and several other governmental agencies, as well as State Forest Services and several schools of forestry. Many of these organizations have lists of publications available for distribution at low cost or free of charge.

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PRINCIPAL TERMS USED IN FORESTRY

Largely taken from U. S. Forest Service Bulletin 61

Accretion — Increase in diameter of height, distinguished from increment, increase in volume.

Accretion Borer — An instrument for determining the growth in diameter of standing trees. It consists of a hollow auger, which, when bored into a tree, extracts a section showing the annual rings.

Accretion Thinning — A thinning made specifically to increase the rate of growth in diameter of the trees which are left standing.

Advance Growth — Young trees which have sprung up in accidental openings in the forest or under the forest cover before reproduction cuttings are begun.

Annual Ring — The layer of wood produced by the diameter growth of a tree in one year, as seen in cross-section.

Arboriculture — The growing of trees singly or in groups for landscaping or shade.

Aspect — The direction toward which a slope faces. The eight main points of the compass, N., N. E., E., S. E., S., S. W., W., N. W., are distinguished in forest description.

Assimilation — In plants, the production of organic matter from inorganic matter.

Back Fire — A fire started purposely some distance ahead of a fire which is to be fought. The back fire is intended to burn only against the wind, so that, when the two fires meet, both must go out for lack of fuel.

Ball Planting — A method of transplanting young trees with balls or lumps of earth around the roots.

Blaze, c. — To mark, by cutting into trees, the course of a boundary, road, or trail.

Board Foot — The contents of a board one foot square and one inch thick. The common unit of measure for logs and lumber in the United States.

Board Measure — The standard of lumber measurement, the unit of which is the board foot.

Body Wood — Cord wood cut from those portions of the stems of trees which are clear of branches.

Breasthigh — At or having a height of 4½ feet above the ground.

Broad-Leaved Trees — Applies to trees whose leaves have a broad flat surface, unlike the needle or awl-shaped leaves of the conifers. Also known as hardwoods.

Buck, v. — To saw felled trees into logs.

Burn — An area over which fire has run, to the noticeable injury of the forest.

Caliper — An instrument for measuring the diameter of trees or logs, usually consisting of a graduated beam to which is attached one fixed and one sliding arm.

Cambium — In trees and shrubs, the layer of new growing tissue between the bark and wood.

Cant Hook — A tool like a peavey, but having instead a toe ring and lip at the end.

Clean Cutting — 1. The cutting of the entire stand. 2. An area upon which the entire stand has been cut.

Clean-Cutting Method — A method in which the entire stand is cut at one time and reproduction is secured by sowing or planting.

Cleaning — A thinning made in a stand which has not reached the small-pole stage. Its main object is to remove trees of undesirable form and species.

Compartment — The unit of area treated in the working plan. The size and the shape of compartments are determined mainly by topographic features.

Compartment Line — The boundary of a compartment.

Composite Forest — A forest in which both seedlings and sprouts occur in considerable number. It may be either pure or mixed.

Conifer — A member of the Pine Family or *Coniferae*. Also known as softwood.

Coniferous — Cone-bearing.

Conk, n. — 1. The decay in the wood of trees caused by a fungus. 2. The visible fruiting organ of a tree fungus.

Coppice — A forest grown from sprouts.

Crown — In silvics, the upper part of a tree, including the living branches with their foliage.

Crown Density — The density of the crowns of the trees in a forest; it is usually measured by the extent to which the ground is shaded.

Cruise, v. — To estimate the amount and value of standing timber.

Cruiser, n. — One who cruises.

Cull — 1. *n.* To take out of a forest by selection a portion of the trees. 2. *n.* A low-grade log or piece of lumber.

Culled Forest — Forest from which cuttings by selection have removed a portion of the trees.

Cut, n. — A season's output of logs.

Cut-Over Forest — Forest in which most or all of the merchantable timber has been cut.

Cutting — A piece of leaf, branch, stem, or root which, when inserted in moist material, is capable of sending out roots and forming a new plant; a slip.

Deaden — To kill a standing tree by girdling it.

Diameter, Breasthigh — The diameter of a tree at 4½ feet above the ground, usually written d.b.h.

Diameter Class — All trees in a stand whose diameters are within prescribed limits.

Dibble — A tool for making holes for planting seeds or young trees.

Dibble In, To — To plant seeds or young trees in holes made with a dibble.

Dominant — Having the crown free to the light on all sides because of greater height.

Dray, n. — A single sled used in dragging logs. One end of the log rests upon the sled.

Duffle, n. — The personal belongings of a woodsman or lumberjack which he takes into the woods.

Firebreak — An opening, ploughed strip of land, or anything which prevents the spread of fires in the forests or elsewhere.

Fireline — A strip kept clear of inflammable material as a protection against the spread of forest fire.

Forest, n. — An area whose principal crop is trees. A forest includes both the forest cover and the soil beneath it.

Forest Capital — The capital which a forest represents. It consists of the forest land, or fixed capital, and the stand.

Forest Cover — All trees and other plants in a forest.

Forester — One who practices forestry as a profession.

Forest Fire — A fire in timberland or woodland. A forest fire may be a ground fire, a surface fire, or a crown fire.

Forest Floor — The deposit of vegetable matter on the ground in a forest. Litter includes the upper, but slightly decomposed portion of the forest floor; humus, the portion in which decomposition is well advanced.

Forest Influences — All effects resulting from the presence of the forest — health, climate (including wind, rainfall, temperature, etc.), stream flow, and economic conditions.

Forest Management — The practical application of the principles of forestry to a forest area.

Forest Nursery — An area upon which young trees are grown for forest planting.

Forest Plantation — Forest growth, established by setting out young trees or by sowing seed.

Forest Policy — The principles which govern the administration of the forest for its best permanent use.

Forest Products — All usable material yielded by the forest. The following classes are distinguished: major products include all wood harvested for any purpose; minor products include all forest products except wood.

Forest Protection — The safe guarding of the forest against any damage not caused by its own growth.

Forestral — Pertaining to forestry.

Forestry — The science and art of making the best permanent use of the forest.

Forest Type — A forest or a part of a forest possessing distinctive characteristics of composition or habit of growth.

Forest Utilization — The most profitable use of forest products, including lumbering, the various wood-using industries such as the wood pulp, wood tannin, cooperage, veneer, excelsior, and similar industries, and the uses to which our woods are put.

Girdling — The act of deadening trees by cutting through the inner bark and sapwood to stop the circulation of the sap.

Ground Cover — All small plants growing in a forest, except young trees, as ferns, mosses, grasses, and weed.

Hardwood, n. — A broadleafed, or dicotyledonous tree.

Heel In, To — To store young trees for planting by laying them against the side of a trench and covering the roots with earth.

Humus — Decomposed organic matter in and on the surface of the soil.

Improvement Thinning — Usually the first thinning made when a forest is put under management, to prepare it for the application of a regular system.

Intolerant — Incapable of enduring heavy shade.

Landing, n. — A place to which logs are hauled or skidded preparatory to transportation by water or rail.

Litter — That portion of the forest floor which is not in an advanced state of decomposition.

Loam — Friable, mellow, rich soil containing much humus.

Locality — An area, considered with reference to forest-producing power. The factors of the locality are the altitude, soil, slope, aspect, and other local conditions influencing forest growth.

Log, To — To cut logs and deliver them to a place from which they can be transported by water or rail; or, less frequently, deliver to the mill.

Log Rule — 1. A tabular statement of the amount of lumber which can be sawed from logs of given lengths and diameters. 2. A graduated stick for measuring the diameter of logs. The number of board feet in logs of given diameters and lengths is shown upon the stick.

Lumber, v. — To log, or manufacture logs into lumber, or both.

Lumberjack, n. — One who works in a logging camp.

Many-aged Forest — A forest through all parts of which many different age classes of trees tend to distribute themselves. When all age classes are thus distributed, the forest is all-aged. These two terms replace selection forest, many-aged being substituted for imperfect selection and all-aged for perfect or ideal selection.

Market, n. — A log 19 inches in diameter at the small end and 13 feet long.

Marking Hatchet — A hatchet for marking trees. A raised die is cut on the head for stamping the face of the blaze.

Mature Forest — Forest so old that growth in height is practically at an end, and diameter growth is decreasing.

Mean Annual Increment — The total increment of a tree or stand divided by its age in years.

Merchantable Length — The total length of that portion of the stem which can be used under given conditions.

Merchantable Volume — The total volume of that portion of the tree which can be used under given conditions.

Mixed Forest — Forest composed of two or more species.

Monoecious — Both staminate and pistillate flowers borne on the same plant (*e.g.*, Black Walnut).

Mulch — Any loose material that protects the soil from frost or evaporation.

National Forest — A forest which is the property of the United States.

National Park — A tract of government land, withdrawn by special act of Congress from settlement, occupancy, or sale, under the laws of the United States, for the benefit and enjoyment of the people.

Nursery — An establishment for the raising of plants.

Overmature Forest — Forest in which, as the result of age, growth has almost entirely ceased, and decay and deterioration have begun.

Overtopped — Having the crown shaded from above, although a side or sides may be free to light.

Overwood — Trees forming the upper story or crown canopy of a forest.

Parasite — A plant or animal that lives upon and obtains its food from other living plants or animals.

Pecky, a. — A term applied to an unsoundness most common in bald cypress.

Pitch Pocket — A cavity in wood filled with resin.

Pitch Streak — A seam or shake filled with resin.

Planting Plan — A detailed scheme for forest planting on a given area.

Planting Site — An area which is to be artificially stocked with forest growth.

Pole — A tree from 4 to 12 inches in diameter, breasthigh. A small pole is a tree from 4 to 8 inches in diameter, breasthigh. A large pole is a tree from 8 to 12 inches in diameter, breasthigh.

Pollard, v. — To invite the production of shoots at the top of a tree by cutting back the crown.

Private Forest — A forest which is the property of an individual, corporation, company, or private institution, contrasted with a public forest.

Protection Forest — A forest whose chief value is to regulate stream flow, prevent erosion, hold shifting sand, or exert any other indirect beneficial effect.

Pruning — The removal of branches from standing trees by natural or artificial means.

Pure Forest — Forest composed of trees of one species. In practice, a forest in which 80% of the trees are of one species.

Reforestation — Bringing back the forest by planting or seeding.

Reproduction — 1. The process by which a forest is renewed. Natural reproduction is the renewal of a forest by self-sown seeds, or by sprouts. Artificial reproduction is the renewal of a forest by sowing or planting. 2. Seedlings or saplings from sprouts or from self-sown seeds.

Reproduction Cutting — Any cutting intended to invite or assist reproduction.

Restock — To renew a forest, either by natural or artificial means.

Rotation — The period represented by the age of a forest, or a part of a forest, at the time when it is cut, or intended to be cut.

Sapling — A tree 3 feet or over in height, and less than 4 inches in diameter, breasthigh. A small sapling is a sapling from 3 to 10 feet in height. A large sapling is a sapling 10 feet or more in height.

Scaler — One who determines the volume in logs.

Seedbed — A specially prepared area, usually in the forest nursery, for the raising of seedlings.

Seed Forest — A forest composed wholly or mainly of trees from seed.

Seedling — 1. A tree grown from seed. 2. A tree, grown from seed, which has not reached a height of 3 feet.

Seed Tree — Any tree which bears seed; specifically, a tree which provides the seed for natural reproduction.

Seed Year — A year in which a given species of tree bears seed; specifically, a year in which a given species bears seed abundantly.

Selection Forest — See many-aged forest.

Selective Logging — Cutting to flexible diameter limits of trees, groups, or areas for immediate profits as well as future yields.

Setting, n. — The temporary station of a portable sawmill, a yarding engine, or other machine used in logging.

Shake — A crack in timber, due to frost or wind.

Shelterbelt — Natural or artificial forest maintained as a protection from wind or snow.

Silvics — 1. The science which treats of the life of trees in the forest. 2. The habit of behavior of a tree in the forest.

Silviculture — The art of producing and tending a forest; the application of the knowledge of silvics in the treatment of the forest.

Skid, n. — A log or pole, commonly used in pairs, upon which the logs are handled or piled.

Skid, v. — 1. To draw logs from the stump to the skidway, landing, or mill. 2. As applied to a road, to reenforce by placing logs or poles across it.

Skid Road — 1. A road or trail leading from the stump to the skidway or landing. 2. A road over which logs are dragged, having heavy transverse skids partially sunk in the ground, usually at intervals of about 5 feet.

Skidway, n. — Two skids laid parallel at right angles to a road, usually raised above the ground at the end nearest the road. Logs are usually piled upon a skidway as they are brought from the stump for loading upon sleds, wagons, or cars.

Slash — 1. The Débris left after logging, wind, or fire. 2. Forest land which has been logged off and upon which the limbs and tops remain, or which is deep in débris as the result of fire or wind.

Snak — A dead standing tree.

Species — A division of a genus, the plants of which seem to be derived from an immediate common ancestor.

Sprout — A tree which has grown from a stump or root. A shoot is a sprout which has not reached a height of 3 feet.

Sprout Forest — A forest consisting wholly or mainly of sprouts.

Sprout Method — That method in which reproduction is obtained by sprouts.

Sprout System — One of the three great systems of forest management, in which reproduction is secured by sprouts.

Spud — A tool for removing bark.

Stand — All growing trees in a forest or in part of a forest.

Standard — A tree from 1 to 2 feet in diameter, breasthigh.

State Forest — A forest which is the property of a state.

Stump — That portion of the tree below the cut made in felling a tree.

Stumpage — The value of timber as it stands uncut in the wood; or, in a general sense, the standing timber itself.

Sucker — A shoot from an underground root or stem.

Sun Scald — An injury to the cambium caused by sudden exposure of a tree to strong sunlight.

Suppressed — Having growth more or less seriously retarded by shade.

Sustained Yield — A plan of managing a forest, whereby yield equals the growth and the growing capital is not impaired. Yield may be annual or periodic.

Tap-Root — A central root running deep into the soil.

Thinning — The removal of a portion of the trees with the object of improving the stand without inviting natural reproduction. The following kinds of thinnings are distinguished; cleaning, improvement thinning, accretion thinning.

Tolerance — The capacity of a tree to endure shade.

Tolerant — Capable of enduring more or less heavy shade.

Tote, n. — To haul supplies to a logging camp.

Town Forest — A forest which is the property of a city, town, or village.

Transpiration — The process by which water is taken up by the roots of plants and given off to the air through the leaves and branches.

Transplant — 1. *n.* A seedling which has been transplanted once or several times. 2. *v.* To take up a young tree and set it out again in another place.

Tree Class — All trees of approximately the same size. The following tree classes are distinguished: seedling, shoot, small sapling, large sapling, small pole, large pole, standard, veteran.

Tree Crown — That part of a tree that is branched, forming a head.

Two-Storied Forest — Comprising on the same area two crown classes, which vary considerably in height.

Undercut — A notch cut in a tree to determine the direction in which the tree is to fall, and to prevent splitting.

Undergrowth — The ground cover, underbrush, and young trees below the large sapling stage.

Underplant — To plant trees under an existing stand.

Underwood — The lower part of a two-storied forest.

Understory — The same.

Valuation Survey — The measurement or other detailed study of the stand.

Veteran — A tree over 2 feet in diameter breasthigh.

Volume — Amount or mass of a tree or stand, expressed in board or cubic feet.

Volume Table — A tabular statement of the volume of trees in board feet or other units upon the basis of their diameter breasthigh, their diameter breasthigh and height, their age, or their age and height.

Volunteer Growth — Young trees which have sprung up in the open, as white pine in old fields, or cherry and aspen in burns.

Weed Tree — A tree of a species which has little or no value.

Windbreak — 1. The breaking of trees by wind. 2. A belt of trees, which serves as a protection from wind.

Windfall — 1. A tree thrown by wind. 2. An area on which the trees have been thrown by the wind.

Wind-Firm — Able to withstand heavy wind.

Wolf Tree — One having wide branches and disproportionately large crown.

Working Plan — A detailed and comprehensive scheme for the best permanent use of a forest.

Yield — The amount of wood at present upon, or which after a given period will be upon, a given area.

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